US Army Corps of Engineers®
Seattle District

Port of Grays Harbor
On Washington's Pacific Coast

Grays Harbor, Washington
Navigation Improvement Project
General Investigation Feasibility Study

FINAL Limited Reevaluation Report

Prepared by:

U.S. Army Corps of Engineers
Seattle District

June 2014

Executive Summary

This Limited Reevaluation Report (LRR) and attached appendices document the U.S. Army Corps of Engineers (Corps) reevaluation of the economic justification of authorized depths and potential environmental impacts of deepening the federal deep-draft navigation channel in Grays Harbor, Washington from the currently maintained depth of -36 feet mean lower low water (MLLW) to the full legislatively authorized project depth of -38 feet MLLW. Congress authorized the Grays Harbor, Washington, Navigation Improvement Project (NIP) in the Water Resources Development Act (WRDA) of 1986, Public Law 99-662. This reevaluation focused on two alternatives that would deepen approximately 14.5 miles of the 27.5-mile federal navigation channel, along with a No Action alternative. Channel deepening would occur from the South Reach upstream to Cow Point Reach adjacent to the Port of Grays Harbor Terminal 4.

The recommended plan, based on the economic and environmental analyses conducted for this reevaluation, is Alternative 3: Deepen Channel to -38 feet MLLW. Alternative 3 maximizes net benefits (average annual benefits less average annual cost) and is the plan that maximizes net benefits for National Economic Development (NED). This is the federal recommended plan. The depth in the recommended plan is the original legislatively authorized project depth and no additional congressional authorization would be required to implement the recommended pan.

The Grays Harbor NIP is located 50 miles west of Olympia on the southwest coast of Washington. Grays Harbor is approximately 110 miles south of the entrance to the Strait of Juan de Fuca and 45 miles north of the mouth of the Columbia River. The cities of Aberdeen, Hoquiam, Ocean Shores, and Westport are located within Grays Harbor. The segment of the channel that was evaluated for deepening is from South Reach upstream to Cow Point Reach.

The 1986 authorization provided for deepening the navigation channel to a project depth of -38 feet MLLW. Post-authorization engineering, environmental and economic studies, reflected in a General Design Memorandum (GDM) of February 1989 resulted in a justified channel depth of -36 feet MLLW from the bar to Cow Point and -32 MLLW feet from Cow Point to Cosmopolis (economic analysis was based on timber industry and log vessels that, at that time, did not need -38 ft MLLW.) The Corps deepened the channel in 1990, in accordance with the 1989 GDM. This is the current depth of annual maintenance dredging.

The reevaluation documented in this LRR and appendices focused on the following problem: As a result of the current channel depth of -36 feet MLLW, and narrow tidal windows, deep draft vessels calling at Grays Harbor have to be partially loaded or experience tidal delays due to insufficient channel depth. The purpose of the economic analysis in this study is to estimate the NED benefits associated with harbor improvements, specifically channel deepening, that are designed to allow for more efficient navigation in Grays Harbor by the existing and projected future deep-draft vessel fleet over the 50 year period of analysis. The Corps economist determines the current vessel fleet composition then projects the future one based on numerous factors such as projected commodity flows, commerce, current fleet, port capacity and limitation. The purpose of the environmental analysis in this study is to assess the potential environmental impacts of channel deepening. This final LRR includes a net benefit analysis. The attached final supplemental environmental impact analysis (SEIS) (Appendix C) includes a full environmental evaluation of potential impacts from deepening the existing channel. Elements of the environmental evaluation are summarized in the LRR. The National Environmental Policy Act (NEPA) document for this study is a SEIS that supplements the 1982 EIS prepared during the NIP feasibility study and a 1989 SEIS.

Non-Federal Sponsor: The Port of Grays Harbor, Washington (Port) is the non-federal sponsor of this study. The Port sponsored the 1982 feasibility study. The Port includes four marine terminals, supported by large, paved, secured cargo yards; an on-dock rail system and more than 104,000 sq ft of on-dock covered storage. Historically, Port business focused on timber, with diversification away from timber starting in 2007. Port growth since 2007 includes over $200M in private investments. Based on 2012 data, approximately 1.9M short tons moved through Grays Harbor; approximately 96% were exports going mostly to Asia. Main commodities include barge and bulk liquid, agricultural processing and autos.

Alternatives Evaluated: For this reevaluation, the project delivery team (PDT), which included Corps representatives from Seattle District (NWS) and Port representatives, evaluated the following three alternatives to address the study objectives and identify a plan that is technically feasible, economically justified and is environmentally acceptable (see Section 5 for detailed descriptions):

- Alternative 1: No Action (Continue Current Channel maintenance to -36 Feet MLLW)
- Alternative 2: Deepen Channel to -37 Feet MLLW
- Alternative 3: Deepen Channel to -38 Feet MLLW

Economic Analysis: The economic feasibility and justification of the recommended plan for this study were determined by comparing the future without-project condition under the No Action Alternative to the future with-project condition under the two action alternatives. This involved comparing the average annual costs and benefits during the 50-year period of analysis. The plan that maximizes net benefits (benefits less cost) is the plan that maximizes net benefits for National Economic Development (NED). This plan is the federal recommended plan. The plan that maximizes NED benefits, based on this economic analysis, is Alternative 3: Deepen Channel to -38 feet MLLW. Transportation cost savings were calculated using the HarborSym model, a planning-level simulation designed to assist in the economic analysis of coastal harbors using data such as port layout, vessel calls and transit rules to calculate vessel interactions within the harbor. (The terms ‘vessel transit’ and ‘vessel call’ appear throughout the tables and the text of the entire report. For purposes of this report a transit can be interpreted as an individual arrival or departure, and a call can be interpreted as a cycle (arrival and departure).) The table below documents this comparison. (Note: For the economic analysis, the No Action Alternative – as a baseline for comparison - does not have a benefit to cost ratio associated with it). However, the depth of the No Action Alternative (i.e. -36 ft MLLW) does have a BCR based on the 1989 GDM. These 1989 numbers are reflected here under No Action.)

NED Analysis Summary

	Alternative 2	Alternative 3
	Deepen channel to -37 ft MLLW	Deepen channel to -38 ft MLLW
Average Annual Benefits	$3,661,000	$7,142,000
Average Annual Cost	$751,000	$1,382,000
NED Benefits	$2,910,000	$5,760,000
Benefit to Cost Ratio	4.9	5.2

Environmental Analysis: For the environmental analysis, the Corps analyzed project-related effects of the three alternatives. The environmental consequences analyses presented in the SEIS determined that the effects of the proposed action on the quality of the human environment, over and above the effects of continuing execution of the present management regime of annual maintenance dredging as evaluated in prior NEPA documentation, would be minor. Alternative 3 would have a slightly greater effect on the natural environment compared to Alternative 2 because the navigation channel would be dredged to a greater depth. Alternative 3 would remove a greater volume of material during the initial deepening of the channel, which could have potentially greater effects on invertebrates, fish and wildlife, and water quality. In addition, Alternative 3 would require the use of two clamshell dredges during dredging of the inner channel reaches, compared to the use of one clamshell dredge under Alternative 2, to allow for a larger volume of material to be dredged during the same in-water work window. The use of two dredges as opposed to one would result in a greater effect on air quality, noise, artificial lighting, and greenhouse gas (GHG) emissions.

Alternative 3, however, would also have a greater benefit to the human environment compared to Alternative 2. Deepening the navigation channel would alleviate tidal delays and light loading of the current vessel fleet, which is currently caused by insufficient channel depths at all tidal stages. Because Alternative 3 would be deepening the navigation channel to its legislatively authorized depth of –38 feet MLLW, compared to –37 feet MLLW under Alternative 2, greater benefits would be achieved under Alternative 3, such as increasing the Port's efficiency to transport goods in and out of the harbor.

Implementation: Implementation of the recommended plan (Alternative 3) would require the removal of 1.752 million cubic yards of sediment to construct, over and above the projected volumes of material dredged and placed in order to maintain the channel at its present -36 feet MLLW depth. Both annual maintenance dredging and deepening from the presently maintained depth to the project depth of -38 feet MLLW must be conducted in the same dredging year. Subsequent annual maintenance dredging requirements would increase by an estimated 107,000 cubic yards. Construction dredging would occur over approximately six months for the inner harbor reaches, approximately 1.5 months longer than current maintenance dredging, and would occur within the same seven month dredge window as current maintenance dredging.

The duration of dredging for the outer harbor reaches would be approximately 1 month, the same as under current maintenance dredging. The total volumes dredged for both annual maintenance and deepening to -38 feet MLLW in the construction year would require an estimated 4,061,000 cubic yards (maintenance volumes to reach -36 feet MLLW, plus deepening volumes for the recommended plan (Alternative 3)).

Project construction (i.e., the dredging process) to deepen the pertinent channel reaches to -38 feet MLLW, including scheduled work periods, types of equipment, and methods for dredged material placement, would be implemented as per current maintenance dredging, with the following exceptions: dredged material for replenishment of the Point Chehalis Revetment Extension Mitigation site would be pumped ashore via submerged/floating hydraulic pipeline moored in Half Moon Bay, a long-reach excavator would be used to remove some material from the Cow Point Reach, material determined to be unsuitable for unconfined aquatic disposal would be transferred and disposed upland, and dredged material would be placed in a shifted Point Chehalis aquatic site during construction of the deepened channel. An additional clamshell dredge and barge would be needed in the inner harbor reaches under this alternative. Dredged materials would be deposited at the existing Half Moon Bay, South Jetty, and South Beach, and upland at the Point Chehalis Revetment Extension mitigation (when feasible) placement sites used during maintenance dredging. The Point Chehalis aquatic site would be shifted approximately 1,000 feet to the north north-west during the construction year to take advantage of deeper water and the existing favorable hydrodynamics that transport material away from the channel. Material unsuitable for open water disposal would be placed at an appropriate upland site.

Approximately 22,400 cubic yards of sediment that would be dredged during construction of the recommended plan from the Cow Point 32a subunit are unsuitable for open-water disposal due to toxicity expressed in the sediment larval bioassay. This material would require appropriate upland disposal (at the former Hoquiam waste water treatment lagoon). Dredged Material Management Unit (DMMU) subunit 32a would be physically surveyed after construction, and a determination would be made at that time whether an additional round of testing is required of that sub-unit prior to any subsequent maintenance dredging episode in that sub-unit's footprint.

In subsequent years, the newly deepened channel would be dredged for maintenance purposes, implemented utilizing the same scheduled work periods, types of equipment, methods for dredged material placement, and placement locations as are used for current maintenance dredging operations. The estimated volume of material dredged from the inner and outer harbor reaches of the navigation channel associated with the recommended plan during the construction year are provided below, as well as the additional increment of maintenance dredged material volume necessitated by the two feet of channel deepening in the subsequent years. The volumes listed include two feet of advance maintenance and two feet of allowable overdepth in each alternative, as well as 15% contingency to account for potential variability in sedimentation rates from year to year. As noted in the table, the economic analysis, employed consistent with Corps project planning principles and policies, assumed deepening would start at -36 ft MLLW, and used the deepening increments below -36 ft MLLW for Alternative 2 and Alternative 3.

Estimated Dredged Material Volumes (cy) to Deepen Channel to -38 ft MLLW

Navigation Channel Reach	Construction Increment Attributable to Channel Deepening from -36 ft MLLW to –38 feet MLLWa	Total Dredged in Construction Yearc	Annual Increase in Maintenance Dredging Attributable to Deepening to -38 feet MLLWd
Inner Harbor Reaches			
Cow Point[b]	348,000	1,158,000	21,000
Hoquiam	359,000	857,000	22,000
North Channel	274,000	519,000	17,000
Inner Crossover	264,000	731,000	16,000
Outer Harbor Reaches			
Outer Crossover	257,000	466,000	16,000
South	250,000	330,000	15,000
Total	**1,752,000**	**4,061,000**	**107,000**

[a] Assumes deepening would begin from –36 feet MLLW and includes advanced maintenance and overdepth dredging volumes, as well as 15% contingency to account for potential variability in sedimentation rates from year to year. Initial channel deepening volumes obtained from the August 2013 condition survey by the Corps vessel *Shoalhunter*.

[b] Volumes include the Cow Point Turning Basin.

[c] Total volume represents neatline volume to -38 feet MLLW, including all O&M dredging above -36 feet MLLW.

[d] Increased annual maintenance attributable to the two foot deepening increment from -36 ft to -38 ft MLLW (Rosati 2004)

Cost Estimate: The cost estimate of the recommended plan (certified 30 May 2014) is as follows: CG FY 2016 Price Level: $17,945,000; CG Fully Funded Amount: $18,301,000; and O&M Fully Funded (50-YR): $60,977,000. The additional volume of material that would be dredged during subsequent operation and maintenance of the recommended plan (107,000 cy) would be an incremental increase above the current O&M volume. The O&M cost of the increment from -36 feet MLLW to -38 feet MLLW would be approximately $0.590 million annually. See Appendix E for the Total Project Cost Summary.

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ist of Abbreviations and Acronyms

AAEQ	average annual equivalent
ARRA	American Recovery and Reinvestment Act of 2009
ATB	Articulated Tug Barge
BA	Biological Assessment
BCR	benefit-to-cost ratio
BNSF	Burlington Northern Santa Fe Railway
CAGR	compound annual growth rate
CG	Construction General
Corps	U.S. Army Corps of Engineers, Seattle District
CBR	crude by rail
CSRA	Cost and Schedule Risk Analysis
cy	cubic yard
DMMP	Dredged Material Management Program
DMMU	Dredged Material Management Unit
E&D	Engineering & Design
EA	Environmental Assessment
Ecology	Washington State Department of Ecology
EIS	Environmental Impact Statement
EOP	Environmental Operating Principles
ER	Engineer Regulation
ERDC	Engineer Research and Development Center
ESA	Endangered Species Act
EPA	see USEPA
EQ	Environmental Quality
FY	fiscal year
GDM	General Design Memorandum
GHG	greenhouse gas
GI	General Investigation
IDC	Interest During Construction
LCA	Local Cooperation Agreement
LRR	Limited Reevaluation Report
M&O	maintenance and operation
MHHW	Mean Higher High Water
MLLW	mean lower low water
NED	National Economic Development
NEPA	National Environmental Policy Act
NIP	Navigation Improvement Project
NMFS	National Marine Fisheries Service
NWD	Northwestern Division
NWS	Seattle District
O&M	operations and maintenance
OSE	Other Social Effects
P&G	Principles and Guidelines
PED	pre-construction engineering and design
PoGH	Port of Grays Harbor
PDT	Project Delivery Team
Port	Port of Grays Harbor

PPA	Project Partnership Agreement
RE	real estate
ROD	Record of Decision
Ro-Ro	roll on, roll off
SEIS	Supplemental Environmental Impact Statement
U&A	Usual and accustomed
UPRR	Union Pacific Railroad
USC	United States Code
USCG	U.S. Coast Guard
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
WDFW	Washington State Department of Fish and Wildlife
WDNR	Washington State Department of Natural Resources
WRDA	Water Resources Development Act

1 Introduction

The Grays Harbor, Washington, Navigation Improvement Project (NIP) Limited Reevaluation Report and attached appendices document the U.S. Army Corps of Engineers (Corps) reevaluation of the economic justification of authorized depths and potential environmental impacts of deepening the federal deep-draft navigation channel in Grays Harbor, Washington from the currently maintained depth of -36 feet mean lower low water (MLLW) to the full legislatively authorized project depth of -38 feet MLLW. This reevaluation focused on two alternatives that would deepen approximately 14.5 miles of the 27.5-mile federal navigation channel, along with a No Action alternative. Channel deepening would occur from the South Reach upstream to Cow Point Reach adjacent to the Port of Grays Harbor (Port) Terminal 4 (Figure 1).

The project delivery team (PDT) for this study included Corps representatives from Seattle District (NWS) and the Port. The study followed the Corps Civil Works planning process for a limited reevaluation, outlined in the Corps Planning Guidance Notebook (Engineer Regulation (ER) 1105-2-100). This limited reevaluation report (LRR) documents the planning process and results, and includes content needed for a limited reevaluation. Elements of the environmental evaluation are summarized in the LRR. The National Environmental Policy Act (NEPA) document for this study is a supplemental environmental impact statement (SEIS) attached as Appendix A that supplements the 1982 EIS prepared during the NIP feasibility study and a 1989 SEIS.

1.1 Purpose and Scope of Limited Reevaluation

The purpose of the economic analysis in this study is to estimate the net benefits (average annual benefits less average annual cost) of deepening alternatives to identify the plan that maximizes net benefits for National Economic Development (NED). NED benefits associated with harbor improvements, specifically channel deepening, are designed to allow for more efficient navigation in Grays Harbor by the existing and projected future deep-draft vessel fleet. The Corps economist determines the current vessel fleet composition then projects the future one based on numerous factors such as projected commodity flows, commerce, current fleet, port capacity and limitation. The purpose of the environmental analysis in this study is to assess the potential environmental impacts of channel deepening. This final LRR includes a net benefit analysis and the attached final SEIS includes a full environmental evaluation of potential impacts of deepening the existing channel. The final LRR and final SEIS also present details of Corps and partner participation needed to implement a plan.

The Port requested in letters to the Corps in 2005 and 2012 to restrict the reevaluation to the legislatively authorized project depth of -38 feet MLLW. This project falls under the Categorical Exemption described in Section 3-2 (Navigation) of ER 1105-2-100. As noted in ER 1105-2-100, for harbor and channel deepening studies where the non-Federal sponsor has identified constraints on channel depths, the Corps is not required to analyze project plans greater (deeper) than the plan desired by the sponsor. Seattle District (NWS) and Northwestern

Division, Corps of Engineers (NWD) agreed to limit the scope of the reevaluation to legislatively authorized depths. As such, the scope of the study is to determine the economic justification and environmental impacts of deepening the navigation channel the remaining two authorized feet.

The PDT evaluated the following three alternatives to address the study objectives and identify a plan that is technically feasible, economically justified, and is environmentally acceptable (see Section 5 for detailed descriptions). The PDT evaluated two deepening increments within the remaining two feet of depth legislatively authorized, to be able to optimize the recommended plan.

- Alternative 1: No Action (Continue Current Channel maintenance to -36 Feet MLLW)
- Alternative 2: Deepen Channel to -37 Feet MLLW
- Alternative 3: Deepen Channel to -38 Feet MLLW

1.2 Study Authority

This limited reevaluation was initiated at the request of the Port to investigate deepening the Grays Harbor navigation channel, which was not constructed to the legislatively authorized depth, based on post-authorization evaluations described below.

Congress initially authorized construction and maintenance of the navigation channel principally through the River and Harbor Act of June 3, 1896 (29 Stat. 202, Ch. 314) and through the River and Harbor Act of August 30, 1935 (49 Stat. 409, Ch. 831); as subsequently amended, among others, by the River and Harbor Act of March 2, 1945 (Public Law 79-14) and the River and Harbor Act of September 3, 1954 (Public Law 83-780).

Congress authorized the NIP in the Water Resources Development Act (WRDA) of 1986, Public Law 99-662. The authorizing legislation is as follows:

PUBLIC LAW 99-662 – NOV 17, 1986

> Section 202 General Cargo and Shallow Harbor Projects
>
> AUTHORIZATION FOR CONSTRUCTION. – The following projects for harbors are authorized to be prosecuted by the Secretary substantially in accordance with the plans and subject to the conditions recommended in the respective reports designated in this subsection, except as otherwise provided in this subsection:
>
> GRAYS HARBOR, WASHINGTON
> The project for navigation, Grays Harbor, Washington: Report of the Chief of Engineers, dated May 4, 1985, at a total cost of $95,700,000, with an estimated first Federal cost of $63,100,000 and an estimated first non-Federal cost of $32,600,000.

The 1986 NIP authorization provided for deepening the navigation channel to a project depth of -38 feet MLLW. The Corps evaluation presented in the 1989 General Design Memorandum (GDM), Grays Harbor, Washington, Navigation Improvement Project resulted in a justified channel depth of -36 feet MLLW from the bar to Cow Point and -32 MLLW feet from Cow Point to Cosmopolis, based on detailed post-authorization engineering, environmental and economic studies. The economic analysis in the GDM was based on timber industry and log vessels that, at that time, did not need -38 ft MLLW. The Corps deepened the channel in 1990, in accordance with the 1989 GDM. This is the current depth of annual maintenance dredging. The project was authorized for a total cost of $95.7 million, but total initial construction was less than $30 million.

Title I of the fiscal year (FY) 2008 Energy and Water Development and Related Agencies Appropriations Act authorized "…restudy of authorized projects..." and provided funds to conduct the reconnaissance (905(b)) phase of the reevaluation study to deepen the channel beyond the current project depth of -36 feet MLLW. NWD approved a 905(b) report in 2009 that concluded there is a federal interest in reevaluating deepening the Grays Harbor NIP project.

1.3 Location and Study Area

The Grays Harbor NIP is located 50 miles west of the city of Olympia on the southwest coast of the state of Washington. Grays Harbor is approximately 110 miles south of the entrance to the Strait of Juan de Fuca and 45 miles north of the mouth of the Columbia River. The cities of Aberdeen, Hoquiam, Ocean Shores, and Westport are located within Grays Harbor (Figure 1).

The federal navigation channel traverses the harbor, providing shipping access between the Pacific Ocean and the lower reaches of the Chehalis River where the cities of Aberdeen, Hoquiam, and Cosmopolis are located. As shown in Figure 2 and Figure 3, the channel is divided into nine distinct reaches. For this reevaluation, the study area includes only the six reaches from the South Reach upstream to Cow Point Reach adjacent to the Port of Grays Harbor Terminal 4 (Figure 1). This segment of the navigation channel is legislatively authorized to -38 feet MLLW, but was implemented and is maintained at -36 feet MLLW.

The Quinault Indian Nation is the only tribe with usual and accustomed fishing (U&A) rights in Grays Harbor. The Chehalis Tribe relies on the fish that migrate up the Grays Harbor estuary to the Confederated Tribes of the Chehalis Reservation. The Corps also coordinates with the Confederated Tribes of the Chehalis Reservation, the Hoh Indian Tribe, Quinault Indian Nation and the Shoalwater Bay Tribe in regards to cultural resources as these Tribes have historically used the Grays Harbor estuary.

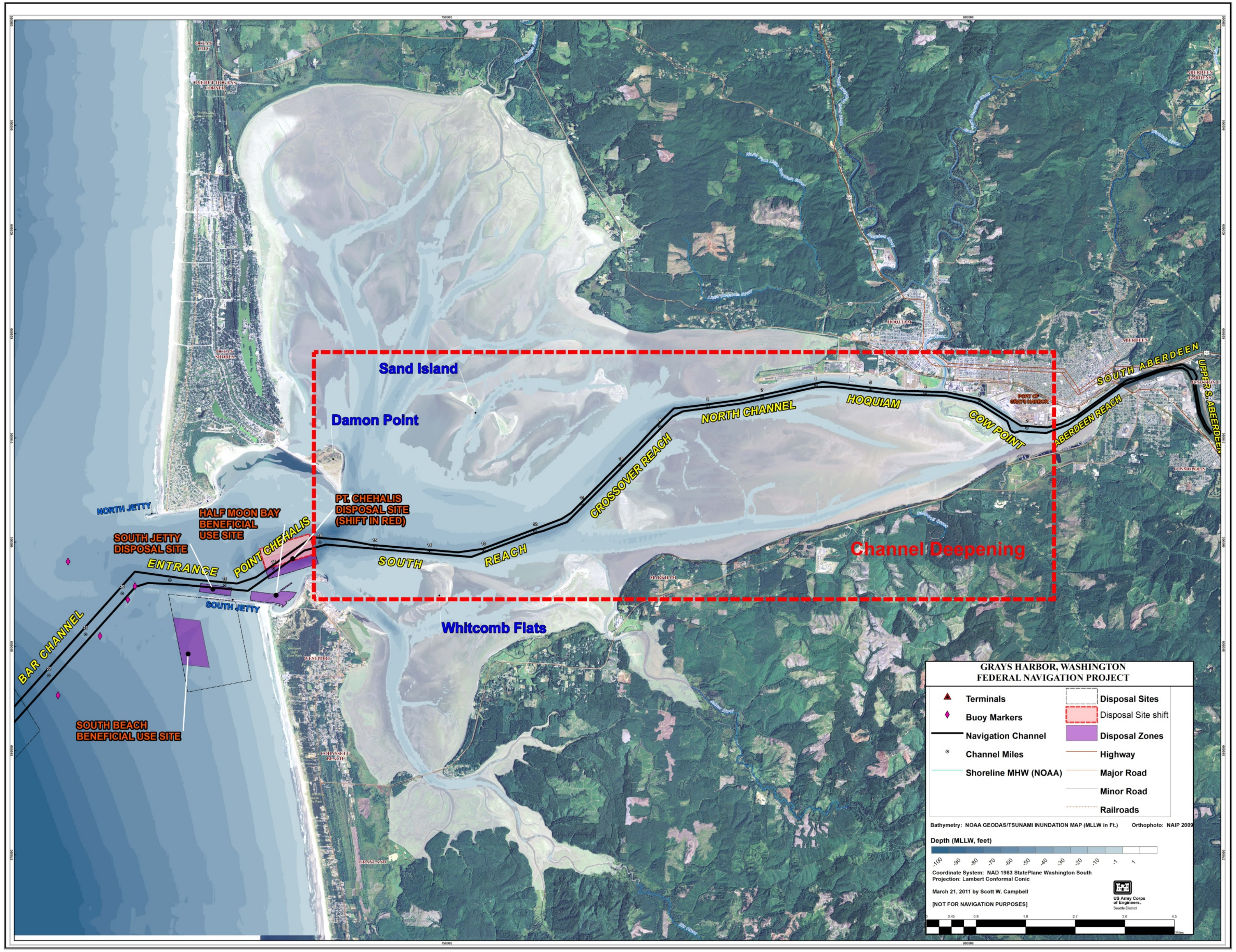

Figure 1: Study Area and Vicinity

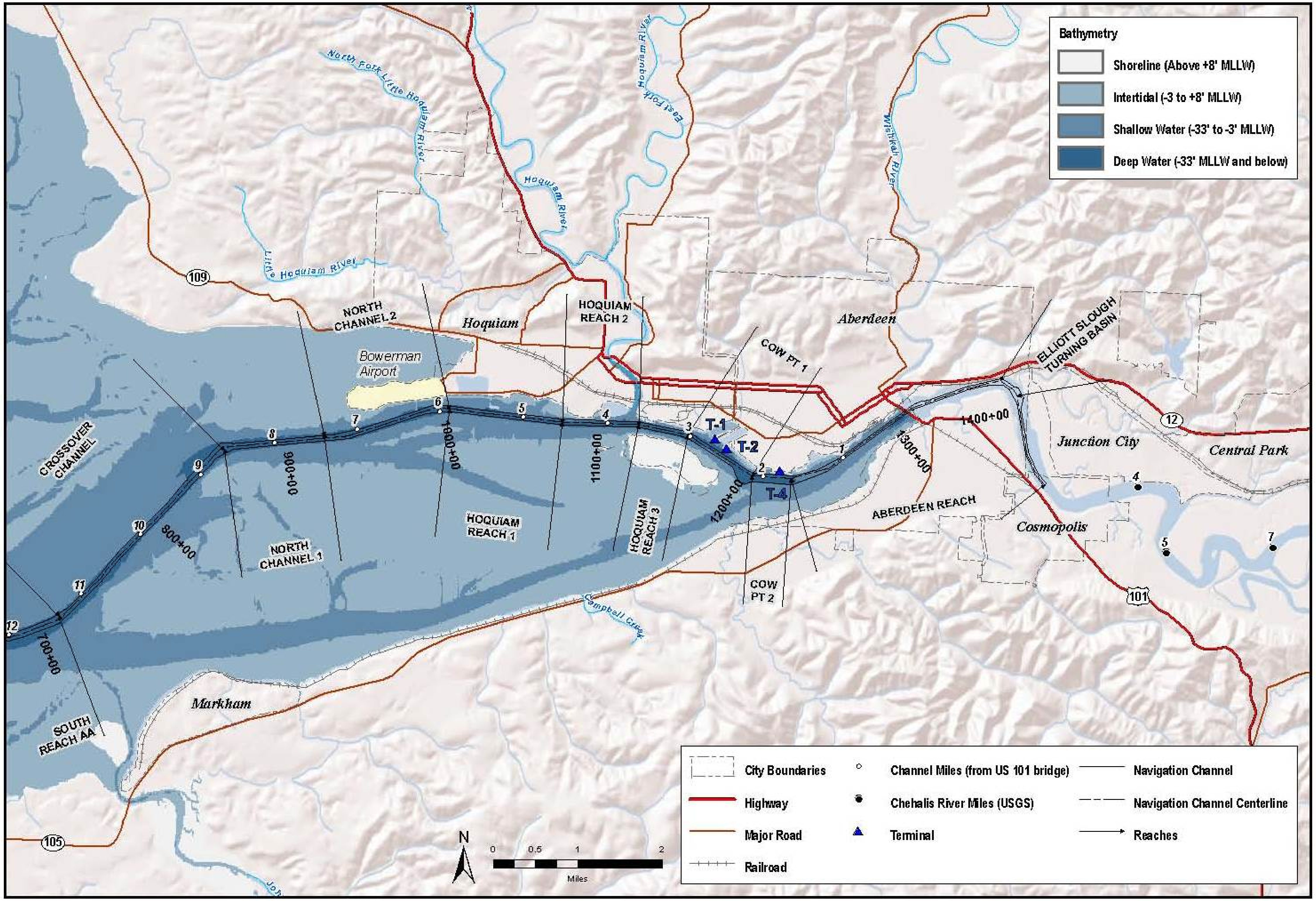

Figure 2: Inner Reaches, Grays Harbor NIP

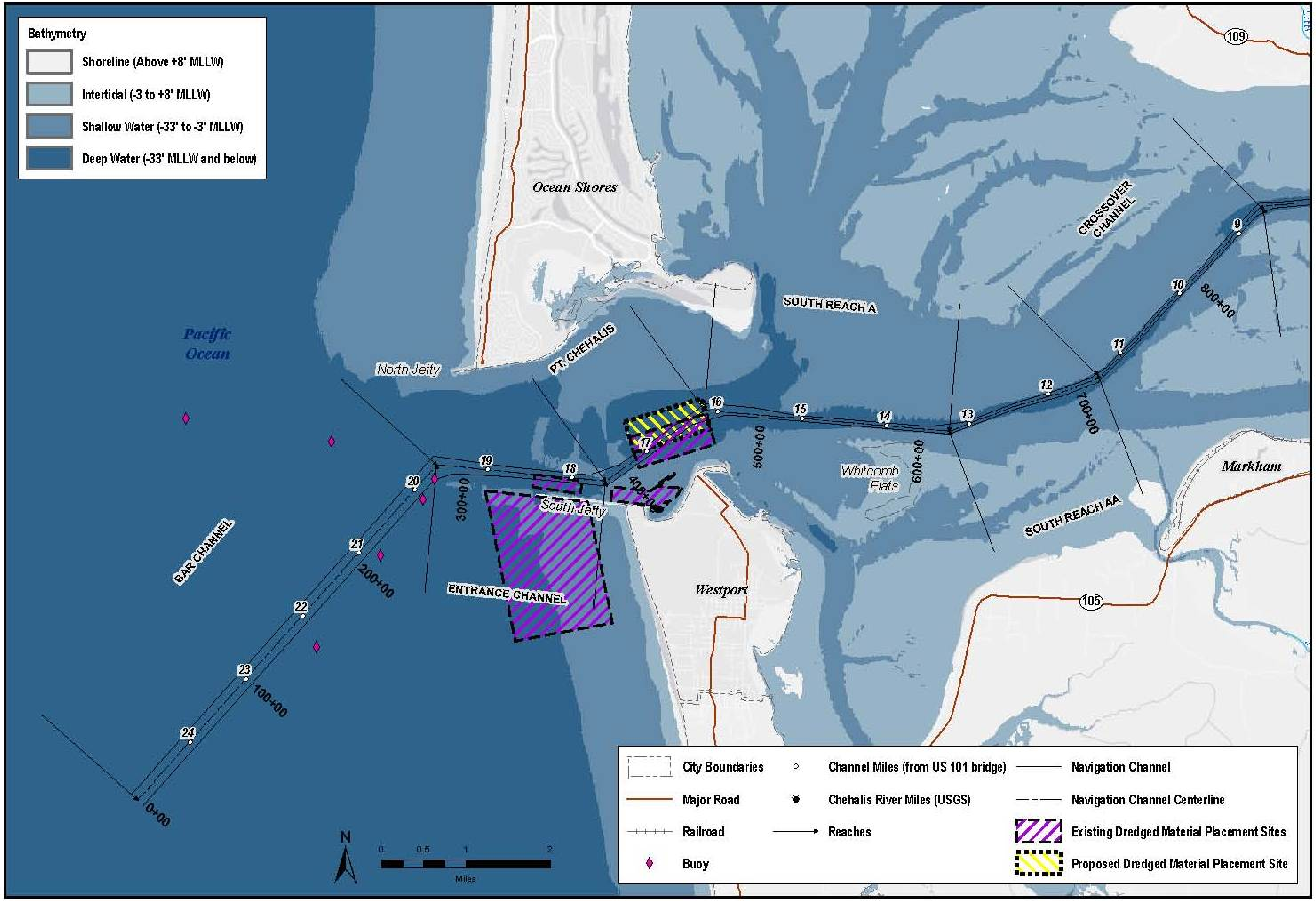

Figure 3: Outer Reaches, Grays Harbor NIP

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1.4 Non-Federal Sponsor

The Port of Grays Harbor, Washington (Port) is the non-federal sponsor of this study. The Port sponsored the 1982 feasibility study. The Port includes four marine terminals, supported by large, paved, secured cargo yards; an on-dock rail system and more than 104,000 sq ft of on-dock covered storage. Historically, Port business focused on timber, with diversification away from timber starting in 2007. Port growth since 2007 includes over $200M in private investments. Based on 2012 data, approximately 1.9M short tons moved through Grays Harbor; approximately 96% were exports going mostly to Asia. Main commodities include barge and bulk liquid, agricultural processing and autos.

1.5 Key Dates for the Grays Harbor Navigation Improvement Project (NIP)

Below are key dates in the project history of the Grays Harbor NIP:

- 1982 – Feasibility Report and Environmental Impact Statement (EIS) completed for channel improvement below -30 feet MLLW; EIS concluded further study warranted for crab mitigation, sediment management and disposal site locations.
- 1986 – WRDA 1986 authorized Navigation Improvement Project to -46 feet MLLW (Outer Harbor) and to -38 feet MLLW (Inner Harbor).
- 1989 – Corps General Design Memorandum (GDM) and Supplemental Environmental Impact Statement (SEIS) documented studies conducted during pre-construction engineering and design (PED); recommended deepening to full depth in Outer Harbor and to -36 feet MLLW in Inner Harbor. (South Reach is in the Outer Harbor for purposes of this LRR, but was not dredged in 1990 to its full depth.) Economic analysis showed justification to deepen to -36 MLLW in Inner Harbor, based on timber industry and log vessels that, at that time, did not need -38 ft MLLW.
- 1990-1991 - Deepening completed.
- 2009 - Reconnaissance 905(b) Analysis and Report: Documented Federal interest in continuing evaluation of implementing legislatively authorized depth of Inner Harbor to -38 feet MLLW.
- 2014 –Final Limited Reevaluation Report: Documents analysis of economic benefits and costs associated with depths of -37 and -38 feet MLLW; Port of Grays Harbor is the non-federal sponsor.
- 2014 –Final Supplemental EIS (SEIS): Documents scope and purpose of project, alternatives considered, and potential environmental impacts of alternatives.

1.6 Description of Authorized Grays Harbor NIP

As noted above, the scope of this reevaluation is limited to evaluating deepening six reaches of the navigation channel. For reference, the primary features of the legislatively authorized deep draft navigation project described in the 1982 feasibility report included other actions: improvement of the existing 24-mile long, 30-foot deep, and segments of the navigation channel to a project depth of -38 feet MLLW; expansion of two existing turning basins; crab and fish mitigation; and replacement of the Union Pacific Railroad (UPRR) bridge at Aberdeen. (The channel itself and twin jetties that secure the mouth of the bay were authorized under the River and Harbor Act of 1896, and modified by subsequent acts.)

1.7 Description of Implemented Grays Harbor NIP

The Corps deepened the Inner harbor of the deep draft channel to -36 feet MLLW in 1990, based on the 1989 Corps GDM, with a deep draft channel over 22 miles long from the Pacific Ocean near Westport inland to Cow Point (near Aberdeen). The deep draft channel is 1,000 feet wide over the entrance bar and through the entrance channel reach and decreases to 350 feet wide near the Port of Grays Harbor terminals at Cow Point. The authorized UPRR bridge replacement was removed from the project scope in FY 1995 at the Port's request, because of non-resolution of political and financial issues related to modification of the bridge. The 1989 SEIS included mitigation for loss of 2 acres of sub-tidal salmon habitat by creation of 4 acres of intertidal habitat plus 18 acres of buffer zone (Junction City area) and placement of oyster shell to mitigate for losses to harvestable Dungeness crabs.

1.8 Problem

As a result of the increase in the average size of vessels calling the Port, the constraints with respect to the current channel depth of -36 feet MLLW, and narrow tidal windows, deep draft vessels calling at Grays Harbor have to be partially loaded or experience tidal delays due to insufficient channel depth.

1.9 Opportunities

Opportunities of a deeper navigation channel include:

- Vessels could operate more efficiently by being fully loaded or reducing delays caused by tidal cycles.
- Increased efficiencies could result in decreased cost to move commodities through the Port of Grays Harbor.
- Vessels carrying more cargo could reach the Port facilities.
- U.S. producers could be provided improved access to world markets.
- Economic competitiveness of producers would be improved.
- Would allow increased beneficial use of dredged materials.

1.10 National Objective

The national or federal objective of water and related land resources planning is to contribute to National Economic Development (NED) consistent with protecting the nation's environment, pursuant to national environmental statutes, applicable executive orders, and other federal planning requirements. Contributions to NED are increases in the net value of the national output of goods and services, expressed in monetary units. Contributions to NED are the direct net benefits that accrue in the planning area and the rest of the nation.

1.11 Planning Objectives

The water and related land resource problems and opportunities identified in this study are structured as specific planning objectives to provide focus for the formulation of alternatives.

These planning objectives reflect the problems and opportunities and represent desired positive changes in the without project conditions.

The primary objective of federal navigation activities is to contribute to the Nation's economy while protecting the Nation's environmental resources in accordance with existing laws, regulation and executive orders. Navigation channels meet the federal objective by reducing transportation costs and improving the efficiency and safety of the deep-draft navigation system, thereby reducing vessel operating costs, resulting in potential savings to the consumer. The specific planning objective for this study is:

- Reduce navigation transportation costs for the existing and projected future traffic of deep-draft vessels, and improve efficiency and reliability of navigation to and from Grays Harbor over the 50-year period of analysis, as feasible and economically justified, within the parameters of the channel as legislatively authorized.

1.12 Planning Constraints

The following planning constraints represent restrictions that should not be violated.

- The evaluation of alternatives to deepen the navigation channel beyond -36 ft MLLW will not re-evaluate the justification of deepening to -36 ft MLLW.
- The evaluation of alternatives to deepen the navigation channel will be limited to alternatives between -36 ft and the full legislatively authorized depth of -38 ft MLLW.

1.13 Assumptions

The PDT developed the following preliminary assumptions. The PDT will review and refine these assumptions during the feasibility study:

- The segment of the channel being evaluated is dredged to its currently justified depth (i.e. -36 feet MLLW project depth plus two feet advance maintenance and two feet allowable overdepth) prior to implementing a recommended plan for a deepening project beyond a project depth of -36 feet MLLW.
- Annual maintenance dredging would occur within the same dredging year as a deepening project.
- Each of the deepening alternatives would require subsequent maintenance dredging.
- The minor channel alignment modification from South Reach to North Channel that Seattle District is pursuing separate from this reevaluation has been previously approved and implemented, resulting in significantly lower dredging volumes in the project area both for O&M and for construction of a deepening alternative. (Dredging volumes assuming completion of this minor channel alignment modification were used in this reevaluation.)
- The reduction in vessel operating costs is cost savings that is passed on to the consumer, thus improving consumers' economic condition and quality of life.

- Approximately one to two percent of the material to be removed by new channel depth dredging (depending which action alternative is implemented) has been found to be unsuitable for open-water disposal. Therefore, a suitable upland disposal site is required.
- Channel dimensions are not a present or expected limiting factor on cargo growth.
- The future without project vessel origin and destination are expected to be the same as the base year of 2017.

1.14 Funding Since Authorization

Table 1 below lists funding for the Grays Harbor NIP since Congress authorized the project in 1986. (Note: The 2004 real estate obligation is a LEERD credit. The non-federal sponsor was given credit for the LEERD amount in the cost share calculation.)

Table 1: Funding Allocations for Grays Harbor NIP Since Authorization

Year	Total Obligations	Construction Obligations	Real Estate (RE) Obligations
1986	$1,020,000	$1,020,000	$0
1987	$440,000	$440,000	$0
1988	$700,000	$700,000	$0
1989	$1,370,000	$1,370,000	$0
1990	$14,701,367	$14,701,367	$0
1991	$396,000	$396,000	$0
1992	$2,889,000	$2,889,000	$0
1993	$506,000	$506,000	$0
1994	$2,104,000	$2,104,000	$0
1995	-$1,365,000	-$1,365,000	$0
1996	$54,000	$54,000	$0
1997	$105,000	$105,000	$0
1998	$49,225	$49,225	$0
1999	$1,206,167	$1,206,167	$0
2000	$20,895	$20,895	$0
2001	-$25,000	-$25,000	$0
2002	-$27,000	-$27,000	$0
2003	$32,000	$32,000	$0
2004	$3,482,417	$9,000	$3,491,417
2005	$20,000	$20,000	$0
2006	$0	$0	$0
2007	$0	$0	$0
2008	$42,245	$42,245	$0
2009	$42,589	$42,589	$0
2010	$59,503	$59,503	$0
2011	$467,133	$467,133	$0
2012	$915,021	$915,021	$0

1.15 Prior Reports and Existing Projects

The PDT used information contained in the following studies and analyses concerning the federal navigation project at Grays Harbor as background material for this reevaluation of the NIP. A detailed list of additional reports that were used as background material for the SEIS is included in Appendix C.

1. **Interim Feasibility Report and Final EIS, Grays Harbor, Chehalis and Hoquiam Rivers, Washington, Channel Improvements for Navigation**, September 1982: Study determined the need for, and feasibility of, improving the safety and efficiency of deep-draft navigation in Grays Harbor. Major features included 24.3 miles of channel improvement from the outer bar through the harbor entrance and estuary past the city of Aberdeen and up the Chehalis River to Cosmopolis (authorized channel would range from -46 feet MLLW at the outer bar and entrance to -38 feet MLLW through the estuary to Port of Grays Harbor terminals at Aberdeen and -36 feet MLLW above port terminals to Cosmopolis), replacement of the Union Pacific Railroad bridge at Aberdeen, construction of three turning basins, placement of dredged material in open-water at the harbor entrance (Point Chehalis and South Jetty sites) and in the ocean and in two confined sites at Aberdeen, and mitigation for lost shallow-water fish feeding habitat and crab mortalities from dredging. Benefit to Cost Ratio of 1.34 to 1.

2. **Grays Harbor, Washington Navigation Improvement Project, Report of Chief of Engineers**, dated May 1985.

3. **Grays Harbor, Washington Navigation Improvement Project General Design Memorandum (GDM) and Environmental Impact Statement Supplement (EISS),** dated February 1989. The GDM recommended scope-reducing design refinements based on detailed engineering, environmental and economic studies. Major features included deepening and widening 23.5 miles of the existing 30-foot channel across the ocean bar (46 feet deep and 1,000 feet wide), through the harbor entrance (46-38 feet deep and 1,000-600 feet wide) and outer harbor (36 feet deep and 350 feet wide), to the inner harbor and river channel (36 feet deep and 350-250 feet wide) plus additional deepening in each reach for advance maintenance dredging (two feet) and allowable overdepth dredging (up to two feet), expansion and deepening of the Cow Point and expansion only of the Elliott Sough turning basins, modification of the UPRR bridge at Aberdeen from swing-span to lift span, and mitigation for lost shallow-water subtidal salmon habitat and crab mortalities from dredging. The authorized UPRR bridge replacement was removed from the project scope in FY 1995 at the Port’s request, because of non-resolution of political and financial issues related to modification of the bridge. Benefit to Cost Ratio (BCR) 1.84 to 1.

2 Evaluation / Decision Criteria

Table 2 summarizes evaluation and decision criteria that are based on the planning objectives and constraints identified above. These criteria were used to evaluate and compare alternatives. These include project-specific criteria, in addition to the four criteria in *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*, referred to as the Principles and Guidelines (P&G). Criteria associated with evaluation of environmental impacts of the alternatives are described in the SEIS (Appendix C of this LRR.)

Table 2: Summary Table of Evaluation/Decision Criteria for Feasibility Study

Criteria	Metric	Threshold/Inventory
Cost	Dollars	Econ Analysis, Cost Engineering estimate
Economic Benefits	Dollars	Econ analysis
Contribution to federal objective (NED)	Y/N	Econ analysis
Meets planning objectives	Y/N	List objective that is met
Avoids planning constraints	Y/N	List any constraints not avoided
Environmental impacts	Degree of impact	To be addressed in SEIS
Completeness	Y/N	Qualitative assessment
Effectiveness	Y/N	Qualitative assessment
Efficiency	Y/N	Qualitative assessment
Acceptability	Y/N	Qualitative assessment

Completeness is the extent to which an alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planning objectives, including actions by other federal and non-federal entities; *Effectiveness* is the extent to which an alternative plan contributes to achieving the objectives; *Efficiency* is the extent to which an alternative plan is the most cost-effective means of achieving the objectives; *Acceptability* is the extent to which an alternative plan is acceptable in terms of applicable laws, regulations and public policies.

The Corps developed Environmental Operating Principles (EOP) to ensure that Corps missions include totally integrated sustainable environmental practices. The EOPs relate to the human environment and apply to all aspects of business and operations. For the purposes of this feasibility study, the EOPs are not used as evaluation criteria. However, the PDT is conducting required NEPA analysis and documentation as a means to address principles of open and transparent processes, and will evaluate alternatives against the P&G criteria and other project-specific criteria listed above to ensure the recommended plan is consistent with protecting the nation's environment, pursuant to national environmental statutes, applicable executive orders, and other federal planning requirements. In addition, the Corps will continue to consider these principles throughout the implementation of the recommended plan.

In additon, the Corps released “12 Actions for Change” in August 2006, following hurricanes Katrina and Rita. These are a set of actions that the Corps will focus on to transform its priorities, processes and planning as part of the planning, evaluation and plan selection process. While this limited reevaluation is a deep draft navigation project - not a flood risk management or coastal storm management project – the PDT applied the general principles of the 12 Actions for Change - risk-informed decision making, comprehensive systems approach, communication, and resiliency - throughout the study process.

3 Existing Conditions

This section describes existing conditions at the time the study was conducted.

3.1 Economic Existing Conditions

The Port of Grays Harbor was founded in 1911 and relied primarily on demand for forest resources (timber). The Port diversified its business in the early 2000s, following shifting global demand for less-costly sources of timber. This diversification involved capital investment of approximately $18 million in rail and rail capacity and an additional $200 million of private investment in port facilities. The Port has seen a steady increase in trade volume over the past decade. The Port's diversification of commodities led to a 42% increase in cargo volume from 2006 to 2012.

3.1.1 Economic Profile of Project Area

The major population surrounding the project location, assumed to be the majority user of the project area with respect to employment and tax income from operations, is the population of Grays Harbor County, Washington. See Appendix A (Economic Analysis) for details. The resident population of Grays Harbor County is approximately 73,000 (Bureau, 2013). The total number of businesses in Grays Harbor County is approximately 1,747, with the highest percent of industries being in retail trade (15.8%) (BEA, 2011). The unemployment rate in December 2012 was approximately 12.4%, approximately 3% higher than the average 9.36% unemployment rate for all counties in the state of Washington (BLS, 2013).

3.1.2 Hinterland Transit Connection[1]

The Port is connected to the surrounding area by the following infrastructure:

- **Highway:** Grays Harbor is connected to its hinterlands by rail and Highway 12, a four-lane state highway connecting Grays Harbor to Interstate 5. This connects to Interstate 90 and provides access to the midwest United States - a major supplier of food and farm product exports – and central area of the United States.
- **Rail:** Rail service to the Port provides access to Burlington Northern Santa Fe (BNSF) and Union Pacific (UP) railroads, via Rail America's Puget Sound and Pacific short line railroad. A rail loop runs through the marine terminal complex providing a continuous rail loop to all three main cargo terminals that allows trains to be continuously loaded or unloaded for movement through Port facilities. Additional auto tracks are under construction to increase auto handling capacity. A second rail loop will be constructed, providing shippers additional import and export handling capacity. An inter-modal 2,800 lineal foot on-dock rail system with direct discharge options and four parallel spurs is available (Harbor, 2013)
- **Air:** Bowerman Airport is approximately five miles from the Port, and is primarily used for general aviation.

[1] "The inland trade region served by a port is called its hinterland. That hinterland usually consists of a number of cargo hinterlands defined by the inland origins or destinations of specific commodities. Collectively, the cargo hinterlands of actual and potential commerce of the project port define the economic study area." (IWR, 2010)

3.1.3 Existing Shipping and Receiving Facilities

Table 3 below summarizes existing marine terminals at the Port.

Table 3: Summary of Existing Shipping and Receiving Facilities at Port of Grays Harbor (Adapted from Port of Grays Harbor web site)

Terminal	Length (feet)	Depth (feet)	Use(s)
Terminal 1	480	-41 MLLW	• Barge & Bulk Liquid • Adjacent uplands storage area • Liquid bulk commodity shipping access to Port customers Imperium Grays Harbor and Westway Terminal Company • Imperium Renewables submitting permit application in 2013 for new storage tanks, rail infrastructure, office space to develop additional 10.7 acres within Port, adjacent to existing Imperium biodiesel plant; Imperium anticipates products will vary over life of facility; may include biodiesel, ethanol, U.S. crude oil, jet fuel, gasoline, diesel, vegetable oil, feed stock (Renewables, 2013). These upgrades to facility and infrastructure are expected to take place regardless of proposed deepening of existing channel. Thus, this development would be reflected in both future-with and future-without project conditions.
Terminal 2	600	-41 MLLW	• Dry and Liquid bulk • Agricultural Processing • Served by rail loop
Terminal 3	600	-41 MLLW	• 150 acre marine industrial site • Deep water terminal • On-site rail (BNSF, UP) • Less than 1 mi from Bowerman Airport • Grays Harbor Rail Terminal, LLC is proposing bulk liquids rail logistics facility at Terminal 3 to handle liquid bulk, primarily crude oil or light oil. Grays Harbor Rail Terminal, LLC conducted a feasibility study in 2013 to explore the option to bring a bulk liquids rail logistics facility to the Port of Grays Harbor. As a result of the findings in the feasibility study, the Port Commission granted Option to Lease T3 property to Grays Harbor Rail Terminal for twenty-four months to allow for further analysis and obtaining of permits to bring the project to shovel-ready.
Terminal 4	1,400	-41 MLLW	• Main general cargo terminal • Break-bulk, Auto and Ro/Ro (Roll-On/Roll-Off Vehicle Based Shipping) • 100,000 sq ft covered warehouse space • Dockside warehousing • Paved uplands • On-dock rail service • Pasha Automotive Services, the leasee of Terminal 4, signed a 20 year agreement with the Port of Grays

			Harbor in 2009 and as of August 2012 moved over 100,000 Chrysler vehicles through the port (Bruscas, 2012).
Weyerhaeuser	1,250	N/A	• Independent terminals for handling log vessels and wood products operated by Weyerhaeuser • Not a major user today or in near future of Grays Harbor Navigation Channel • Moving little to no major volumes of commodities, and, as such, not being factored into economic analysis • Located upriver of proposed NIP improvements

3.1.4 Tonnage

After the initial steep decline in tonnage in the late 1990s, the Port has seen a general increase of tonnage movement (Figure 4). All 2012 tonnage data was provided by the Port of Grays Harbor Pilot Logs, as the Waterborne Commerce Statistics Data Center information was not available at the time of this analysis. The revival of the Port is due in large part to the Port's strategy change to diversify services and commodities. Figure 4 shows that in 2006 the Port moved approximately 1.28 million short tons and by 2012 was moving approximately 1.9 million. This represents a compound annual growth rate (CAGR) of approximately 6.8%. Data displayed has a standard deviation of approximately 290k and displays an above average CAGR. The trend displayed is not expected to continue at the current CAGR of 6.8% but is expected be somewhere around 1-2% depending on the commodity.

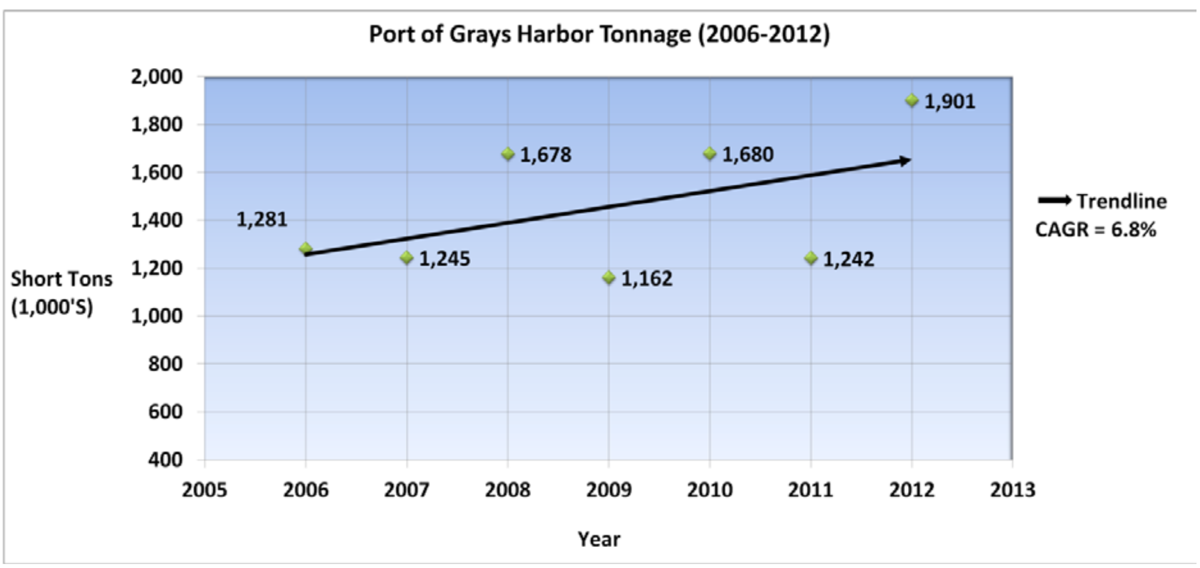

Figure 4: Port of Grays Harbor Historic Tonnage

As of 2012, approximately 1.9 million short tons were moved through Grays Harbor. Of the 1.9 million tons moved, approximately 96% is export based going to places such as China and the Philippines (Figure 5). Note that the same type of summary values in the tables presented herein may not exactly match each other due to the rounding of values and/or to values obtained from different sources. These differences are insignificant and as such do not affect the analysis.

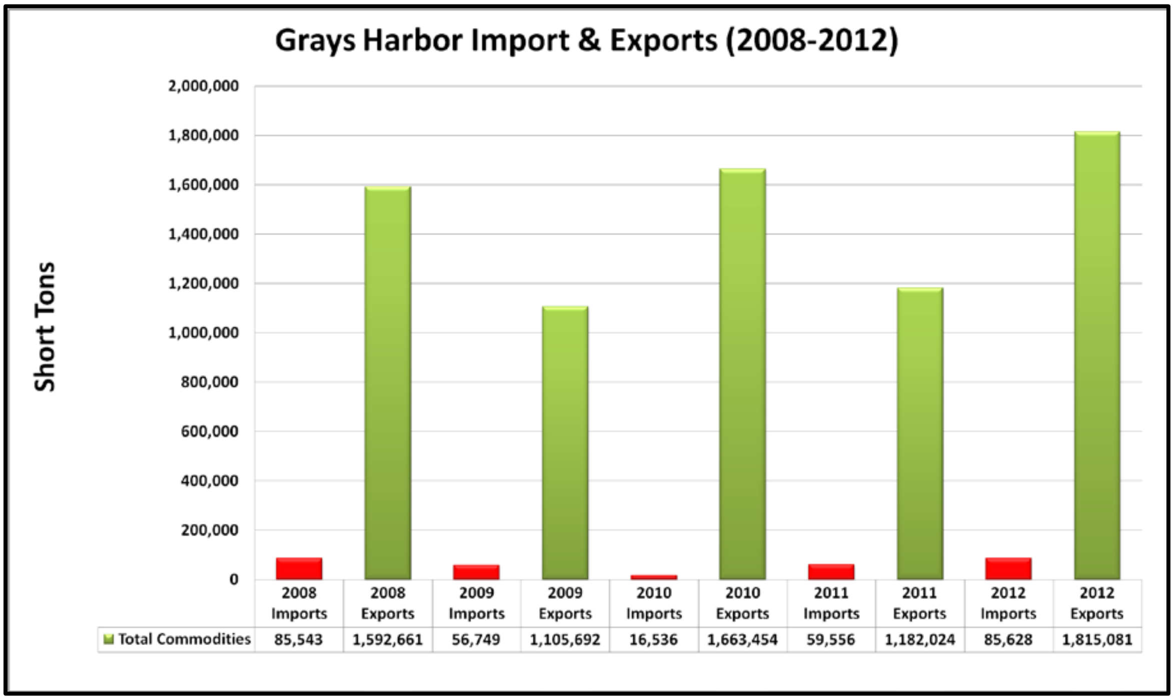

Figure 5: Historic Import and Export Tonnage by Year

3.1.5 Historic and Existing Commodity Movements

Historically, the Port relied heavily on forest products such as lumber and wood chips to support business activities. Figure 6 shows the 2012 commodity breakdown, which is more diverse, with the Port's new main line of businesses, based on pure tonnage moved, of food and farm products (74%, which includes soybean, soybean meal, distilled dried grains, and corn), followed by forest products (13%), manufactured equipment such as vehicles (8%), and chemicals (5%). These were not further broken out due to the fact that these commodities use similar, if not the same, modes of transportation such as vessels, routes, and rail car. Thus, any benefits associated with Food and Farm Products would apply across all the aforementioned commodities.

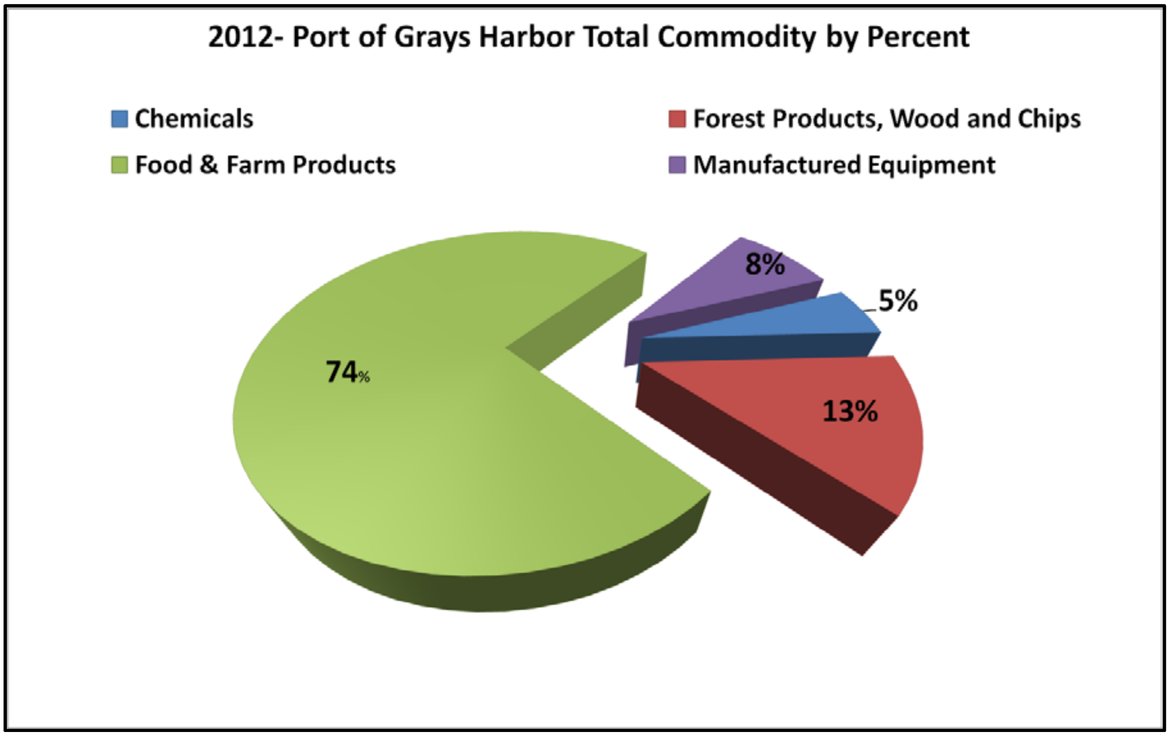

Figure 6: Existing Commodity Breakdown

Table 4 displays total annual commodity tonnages at the Port from 2006 - 2012, and associated annual growth rate for each year. The CAGR for this period is approximately 6.8%. This can mostly be attributed to strong demand for soybean and other agricultural products from China and the Philippines. The variance or fluctuations seen in the Port tonnage year over year can be attributed to multiple factors. The drop in tonnage in 2009 is directly related to the 2008 financial crisis when world demand of goods and services dropped. In addition, other year's fluctuations in the tonnage moved through the Port are due to environmental factors such as commodity (soybean prices), exchange rate fluctuations, and inventory availability.

Table 4: Grays Harbor Total Annual Cargo (in Tons)

Grays Harbor Total Annual Cargo Short Tons		
Year	Total Tons	Annual Growth Rate (year-to-year)
2006	1,280,578	
2007	1,244,705	-2.8%
2008	1,675,699	34.6%
2009	1,162,441	-30.6%
2010	1,679,991	44.5%
2011	1,241,580	-26.1%
2012	1,900,708	53.1%
Compound Annual Growth Rate (2005-2012)		6.8%

The volume of both manufactured equipment (vehicles) and food and farm products (soybean) that moved through the Port increased significantly from 2008 through 2012 (see Table 5.) The table left out unknown commodities, primary manufactures and oil as they are historically not a substantial volume moved. Table 5 does not include unknown commodities, primarily manufactures and oil as they are historically not a substantial volume moved.

Table 5: Short Ton by Commodity

Port of Grays Harbor Historic Short Ton by Commodity					
	2008	2009	2010	2011	2012
Chemicals	90,650	66,793	14,964	131,084	94,082
Forest Products, Wood and Chips	988,223	331,205	530,807	347,887	251,814
Food & Farm Products	595,672	756,825	1,094,985	677,797	1,396,313
Manufactured Equipment	1,154	7,618	32,413	84,811	158,499
Total Commodities	1,678,204	1,162,441	1,679,991	1,241,580	1,900,708

The preliminary 2013 cargo volume and vessel call data are approximately 2.65 million short tons with 102 vessel calls.

From a pure dollar perspective, the Port's most valuable export is manufactured equipment, which consists mostly of Jeep, Chrysler, and Dodge vehicles shipped via Roll On Roll Off (Ro-Ro) vessels. The change from forest based products to more valuable market commodities, such as vehicles, has led to a drastic increase in the value of commodities moving through the Port, which has increased from approximately $255 million in 2006 to nearly $2 billion in 2012 (Resources, Institute for Water, 2013) representing a 665% increase in the value of the goods being shipped (see Figure 7.)

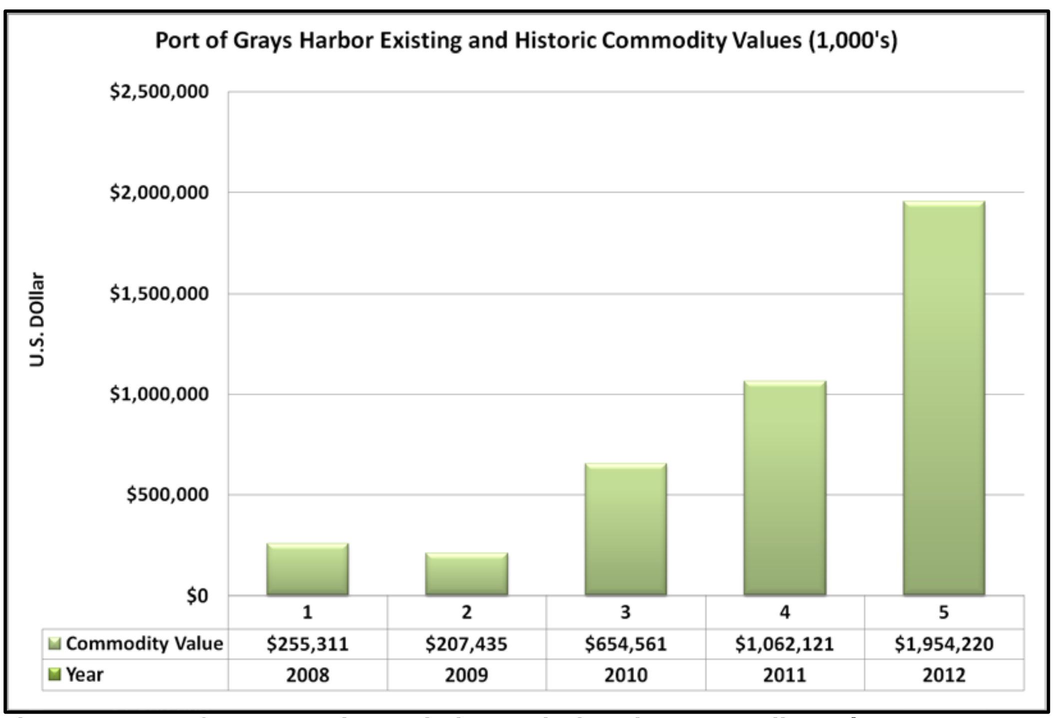

Figure 7: Port of Grays Harbor Existing and Historic Commodity Values

3.1.6 Origins and Destinations

Figure 8 shows commodity origins and destinations. The majority of cargo shipped through the Port in 2012 (59%), principally exports, went to Southeast Asian countries. The Philippines was the prevailing trade partner and is the furthest trade partner away from the Port, based on average nautical miles traveled by all vessels. China is the second largest trade partner, at approximately 21% of total trade volume by short ton. Agricultural and manufactured equipment is the predominant commodity with respect to Port exports to China.

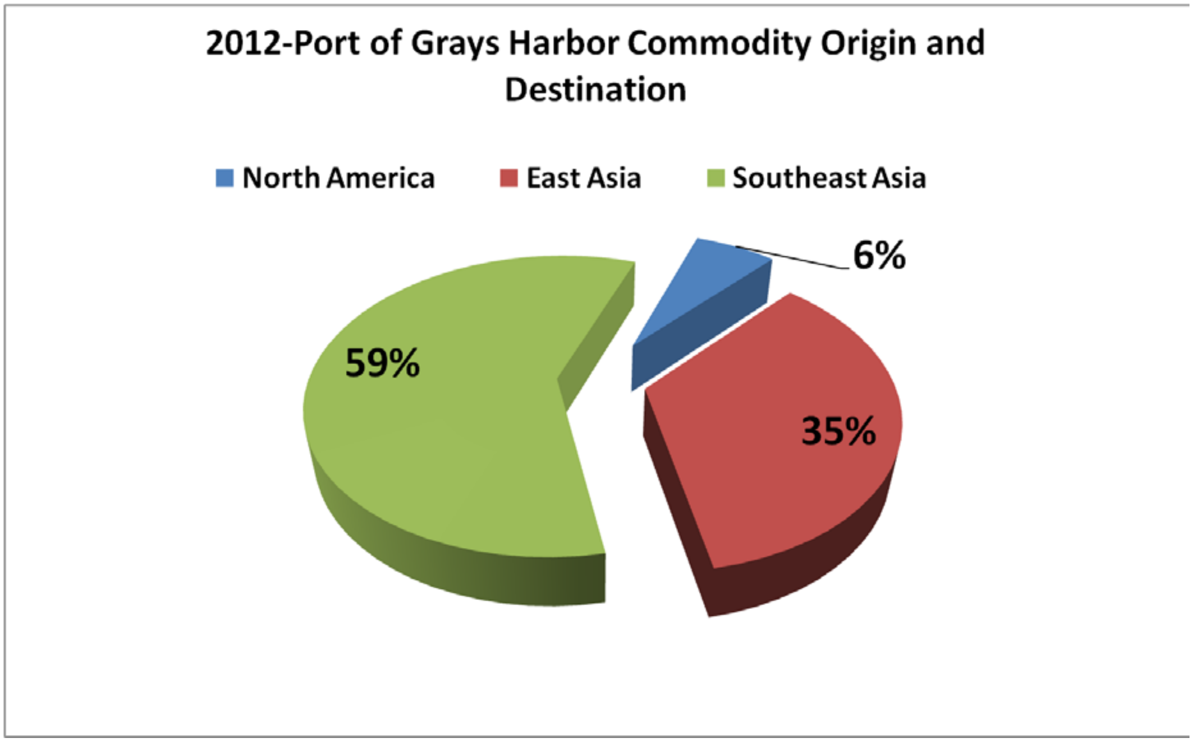

Figure 8: Commodity Origin and Destination

Each major trade partner was aggregated into 1 of 3 specific route groups for the simplicity of analysis. Origin and destination ports of the goods moving through the Port of Grays Harbor were reviewed and found to be more than adequate, with respect to depth and infrastructure, to handle the vessels moving from and to the Port of Grays Harbor. The Ports of Call were aggregated based on locations and distances with respect to one another. For example; the East Asia trade group includes countries such as China and Vietnam as they are relatively close to each other and the distances from the Port of Grays Harbor are similar (see Table 6.) The distances from and to the Port of Grays Harbor from and to the port of call were determined through the use of seadistances.com (SEA DISTANCE - VOYAGE CALCULATOR, 2013).

Table 6: Grays Harbor Port of Call Characteristics

Grays Harbor Port of Calls				
North America				
Port Name	Average Nautical Miles	Route Group	2012 Short Tons	% of Sub-total
United States	44	RtGrp1	70,559	4%
Vancouver Canada	23	RtGrp1	47,238	2%
Lazaro Cardenas, Mex	2,129	RtGrp1	4,423	0%
East Asia				
Port Name	Average Nautical Miles	Route Group	2012 Short Tons	% of Sub-total
S. Korea	4,573	RtGrp2	70,066	4%
China	5,030	RtGrp2	392,720	21%
Japan	3,976	RtGrp2	83,425	4%
Vietnam	6,542	RtGrp2	42,825	2%
Russia	4,208	RtGrp2	79,169	4%
Southeast Asia				
Port Name	Average Nautical Miles	Route Group	2012 Short Tons	% of Sub-total
Philippines	5,889	RtGrp3	1,037,923	54%
Indonesia	7,353	RtGrp3	35,666	2%
Newcastle, AU	6,617	RtGrp3	44,847	2%
TOTAL			1,908,861	100%

3.1.7 Existing Vessel Fleet

Vessels calling at the Port were broken down into four main categories: Articulated Tug Barge (ATB) Tanker, Bulker, and Ro-Ro because these three vessel types account for most - if not all - of the vessel types calling the Port that would potentially benefit from the proposed channel deepening project. All vessels traversing the Port of Grays Harbor are potentially adversely affected by the existing channel depths due to the fact that there are congestion externalities that exist. For example, if a larger vessel has priority over a smaller vessel then the smaller vessel will still have to wait for the larger vessel to enter and clear the channel. So even though a shallower draft vessel may be well within the depths needed to traverse the channel it could still remain on standby due to the wait imposed on the larger ship that does have a depth constraint. In addition, the three categories were chosen to help narrow down the time and cost associated with analyzing every type of vessel that has, or potentially could, call on the Port. These four categories were further broken down in the HarborSym program (a Monte Carlo simulation model for deep draft navigation economics) to account for the different sizes of each vessel type. For example, Tankers were broken down into Small Tanker, Medium Tanker, and Large Tanker (Table 7).

Table 7: Vessel Description and Capacity

Vessel Description and Capacity	
Vessel Description	**Dead Weight Tons**
ATB 30k	15,001-25,000
Bulker 10k	1,500-15,000
Bulker 20k	15,001-25,000
Bulker 30k	25,001-35,000
Bulker 40k	25,001-45,000
Bulker 50k	45,001-55,000
Bulker 60k	55,001-65,000
Bulker 70k	65,001-75,000
Bulker 80k	75,001-105,000
Ro-Ro 10k	1,500-15,000
Ro-Ro20k	15,001-50,000
Tanker-Small	4,000-50,000
Tanker-Medium	30,000-70,000
Tanker-Large	60,000-80,000

This allows the simulation program the ability to sort the different Tanker vessels calling the ports into different sizes. The types of vessels and the major route group associated with each vessel type are broken down by percentage in Table 8 below.

Table 8: Vessel Class by Route Group

Vessel Class Route Group			
Class Name	**North America**	**East Asia**	**Southeast Asia**
Tanker	**0%**	**4.0%**	**2.3%**
Bulker	**95.9%**	**73.0%**	**97.7%**
Ro-Ro	**4.10%**	**22.0%**	**0%**

Tankers:
In 2014, tankers currently do not play a major role in commodity movements within the Port. However, this is expected to change in the near (1-year) to intermediate (5-year) future (see Section 4.1) and, as such, will form part of the without-project condition

under this analysis. The future tanker fleet that will be calling the Port of Grays Harbor will be moving domestic crude and as such will be required to use domestic vessels in compliance with the Jones Act. The tanker fleet that will be calling the Port of Grays Harbor – possibly as early as the baseline year of 2017 and likely under the with-project condition – will be moving crude. These crude-carrying vessels are expected to be of different average characteristics than the small number of tankers historically calling at Grays Harbor, as displayed in Table 9. The draft of the future tanker vessels is expected to have a maximum design draft of -36 feet or less. The projected increase in the number of crude-carrying vessel calls at Grays Harbor is independent of project implementation. Discussions with the Port of Grays Harbor and the companies that are proposing to bring crude by rail projects to the Port have indicated that permit applications for infrastructure enhancements needed to facilitate the movement of crude by rail through the Port would be initiated regardless of an increase in the depth as proposed by the Corps. Conversations with future and existing tenants that are proposing to move crude have further indicated that the crude vessels expected to utilize the Port of Grays Harbor would be the same in the future with-project and future without-project conditions, consistent with the discussion of efficient use of vessel size classes. The current deepening project would not make possible the entry of the tankers as they can enter under the existing conditions (-36 MLLW).

There is speculation that Canadian crude would utilize the Port of Grays Harbor and thus the requirement to utilize Jones Act Fleet would not be in effect. Despite the provider of the crude the vessel sizes that will be utilized are expected to be the same due to fleet availability and preferences of the shipping companies.

Tankers used in 2012 visited from South Korea and the Philippines and accounted for 4% (Grays Harbor Pilot Logs, 2013) of East Asia and 2.3% of Southeast Asia's Vessel Class Route Group (Table 8.) The commodity associated with these movements is methanol, a liquid bulk item. Table 9 lists average tanker vessel characteristics.

Table 9: Tanker Characteristics

Tanker Vessel Characteristics (Average)						
Net Short Tons	Gross Short Tons	DeadWt Short Tons	Length (ft)	Breadth (ft)	Depth (ft)	Design Draft (ft)
7,769	19,794	27,600	558	88	35	36

Bulker: Bulker vessels make up the largest portion of all traffic entering the Port by pure tonnage. The overwhelming majority of commodities loaded on bulk vessels are bound for the Philippines and China. The largest bulker has a design draft of approximately 47 feet and is used as a bulk agricultural vessel for exports to China. In 2012 the Port experienced approximately 25 calls from bulker type vessels. Table 10 lists average dimensions for bulker type vessels used in 2012 at the Port.

Table 10: Bulker Characteristics

Bulker Vessel Characteristics (Average)						
Net Short Tons	Gross Short Tons	DeadWt Short Tons	Length (ft)	Breadth (ft)	Depth (ft)	Design Draft (ft)
17,697	32,549	53,328	624	101	34	39

Roll-On-Roll-Off (Ro-Ro): In 2012 the Port experienced approximately 20 Ro-Ro vessel callings. These vessels were used to move autos and other manufactured equipment. Most of the export vehicles were shipped to East Asian countries such as China, Japan and Russia. Table 11 lists average Ro-Ro vessel characteristics.

Table 11: Ro-Ro Characteristics

Ro-Ro Vessel Characteristics (Average)						
Net Short Tons	Gross Short Tons	DeadWt Short Tons	Length (ft)	Breadth (ft)	Draft (ft)	Design Draft (ft)
14,463.64	47,671.88	15,023.54	594.44	100.85	28.00	29.21

Ro/Ro's are not necessarily directly adversely affected by existing channel depths due to the lower draft (~29 feet) but they are affected indirectly due to the aforementioned congestion externalities as well as the reduced tidal (time) window available to enter and exit the harbor.

The average size of deep-draft vessels calling at the Port is increasing in all dimensions (Table 12).

- The number of departures increased from 59 calls in 2005 to 83 calls in 2012, an increase of 43%.
- Deadweight tons, the carrying capacity of the vessel including cargo weight fuel and stores has increased from 28,300 tons in 2005 to 35,300 tons in 2012, an increase of 25%.
- Vessel length has increased from 547 feet in 2005 to 619 feet in 2012, a 13% increase.
- Vessel beam (breadth or width) has increased from 87.6 feet in 2005 to 101.8 feet in 2012, an increase of 16%.
- Design draft (the distance from the design waterline to the bottom of the keel, which is the maximum depth that the vessel may be loaded to) has increased from 32.5 feet in 2005 to 35.9 feet in 2012, an increase of 11%.
- Arrival draft (the actual draft of the vessel given the amount of cargo it carries when arriving at port) has increased from 22.4 feet in 2005 to 25.0 feet in 2012, an increase of 12%.
- Departure drafts (i.e. the actual draft of the vessel given the amount of cargo it carries when departing from port), which have a greater impact on Port operations than arrival or design draft because most of the cargo consists of outbound exports and is composed of heavier products, have increased from 30.3 feet in 2005 to 31.9 feet in 2012, a 5% increase.

Table 12. Vessel Size Trends

Year	Average Vessel Dimensions at Port of Grays Harbor					
	Number of Calls	**Deadweight Tons**	**Length**	**Breadth**	**Design Draft**	**Arrival/ Departure Draft**
Arrivals						
2005	58	28,275	547.4	87.6	32.5	22.4
2006	33	29,561	571.1	89.5	32.8	22.5
2007	45	22,764	500.6	78.7	29.5	21.5
2008	48	31,710	557.1	90.1	34.0	23.0
2009	47	29,153	582.8	94.6	34.0	24.0
2010	66	32,980	603.0	98.8	34.3	23.0
2011	72	28,084	574.9	94.3	32.6	24.4
2012	82	35,259	618.9	101.8	35.9	25.0
Increase 2005–2012	41%	25%	13%	16%	11%	12%
Departures						
2005	58	28,767	547.0	87.3	32.3	30.3
2006	34	30,365	572.6	90.0	33.1	31.6
2007	44	22,551	498.8	78.3	29.5	26.4
2008	47	31,065	555.7	107.2	33.8	31.6
2009	48	30,554	584.0	94.9	34.2	30.9
2010	65	32,528	602.7	98.7	34.0	31.4
2011	71	27,811	582.9	95.7	33.0	30.0
2012	83	35,376	618.8	101.7	35.8	31.9
Increase 2005–2012	43%	23%	13%	16%	11%	5%
Source: Port of Grays Harbor 2013.						

Impact of Tide Height on Marine Operations

The constraints of the existing channel are affecting vessel loads and operations. This trend is further explored in the Table 13, which documents the number of calls during which the actual draft was 32 feet or more. The existing channel depth is 36 feet. Without accounting for tidal fluctuation and assuming an underkeel clearance requirement of 3.5 feet, vessel drafts are limited to 32 feet. Arrivals and departures that exceed 32 feet require timing of the tides to utilize greater depths of water.

As discussed above, the depth of the navigation channel mainly affects departures. There were 20 calls in 2005, representing 34% of all calls, with a vessel draft of 32 or more. By 2012, the number of calls in this category (actual departing vessel draft of 32 feet or more) had reached 34 calls, accounting for 41% of all calls. In addition, vessel departures frequently exceeded 36 feet, with some departing at a draft of 40 feet.

Table 13: Number of Departures 32 Feet Deep and Over

Year	Depth (feet)									Subtotal 32 feet +	Total Calls	% Over 32 feet
	32	33	34	35	36	37	38	39	40			
2005	10	2	1	2	3	-	1	1	-	20	58	34%
2006	8	5	1	-	1	1	-	-	-	16	34	47%
2007	5	2	1	3	-	-	-	-	-	11	44	25%
2008	9	8	1	3	1	1	-	-	-	23	47	49%
2009	5	3	2	2	4	5	-	-	-	21	48	44%
2010	9	7	5	3	4	2	2	-	-	32	65	49%
2011	1	5	7	2	6	7	-	-	-	28	71	39%
2012	-	4	4	1	11	4	4	6	2	34	83	41%
Increase 2005–2012										70%	43%	
Source: Port of Grays Harbor 2013.												

As shown in Table 14, departing vessels are maximizing the use of tides. During the past 3 years, more than 90% of vessel departures have "utilized" a tide of more than 5 feet. In recent years, an increasing number of vessels have "left" at tides from +6 to +10 MLLW.").

Table 14. Departures by Height and Controlling Tide

Departures	Controlling Tide (feet)							
	5	6	7	8	9	10	Over 5 feet	% of Total Departures
2005	8	9	15	7	3	1	43	74%
2006	6	11	8	4	1	-	30	88%
2007	9	7	7	6	3	1	33	75%
2008	10	7	14	7	3	-	41	87%
2009	8	16	10	7	1	-	42	88%
2010	9	19	14	11	5	1	59	91%
2011	13	24	16	10	3	1	67	94%
2012	8	26	25	9	8	-	76	92%
Source: Port of Grays Harbor 2013.								

A typical daily tidal cycle in Grays Harbor is shown in Figure 9. The typical window of availability (defined as the number of hours during which the height of the tide exceeds the required height) is approximately 14 hours for a ship requiring a minimum of a 5-foot tide (above MLLW), decreasing to 2 hours at a 9-foot tide (above MLLW). As a result, the probability of the tide meeting vessel requirements is approximately 56% for a 5-foot tide (above MLLW) but only approximately 8% for a 9-foot tide (above MLLW). The tide height must meet the vessel's requirements during the entire transit through channel segments of restrictive depths, which may extend several hours. Percentages represent the tidal cycle for May 14, 2013, the day of the charted data, and only apply to this date. However, these percentages represent approximately the amount of time the tide is sufficient to meet vessel requirements for navigation in the channel.

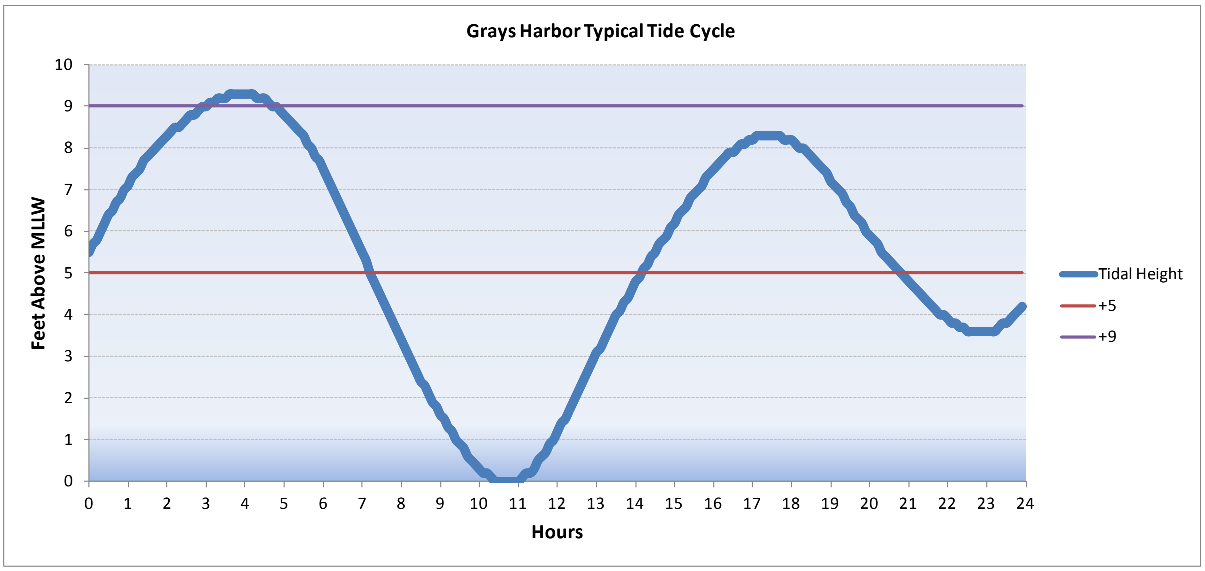

Figure 9: Grays Harbor Typical Daily Tidal Cycle

(Source: Nautical Software, Inc. 2006. Note: Tidal cycle for May 14, 2013.)

As stated earlier, as a result of the current channel depth of -36 feet MLLW and the narrow tidal windows, deep draft vessels calling at Grays Harbor have to be partially loaded or experience tidal delays due to insufficient channel depth. Figure 3 below shows all the vessels, design versus departure draft depth, which entered the Port of Grays Harbor during 2012. The blue indicates the design draft of each vessel and the pink indicates the greatest draft utilized during the vessel call, either inbound or outbound. From the figure you can see that as the vessel design draft gets larger so too does the amount of blue showing. This blue indicates that vessels are partially loaded (constrained) during their arrival or departure depending on whether the vessel is exporting or importing, and as the vessels get larger so too does the discrepancy between the design drafts and the transit drafts.

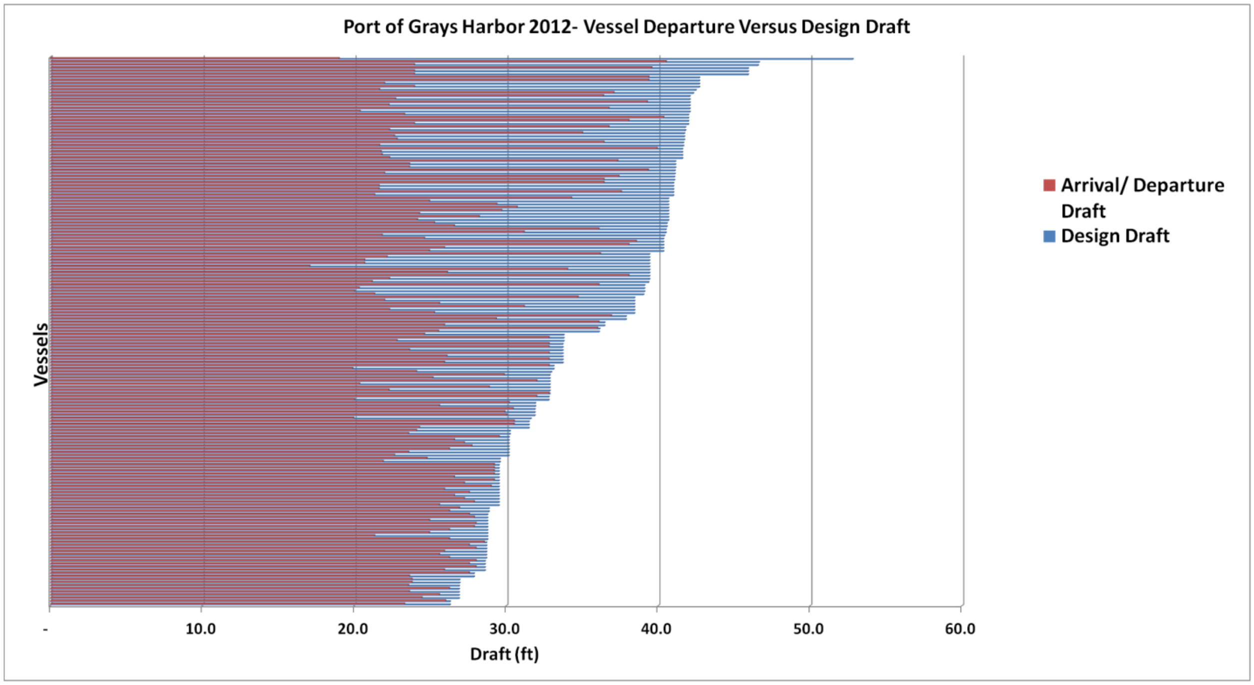

Figure 10: Vessel Departure Draft versus Vessel Design Draft

In 2012, the Port of Grays Harbor had approximately 44 vessels calling on the Port with vessel design drafts that are equal to or exceed -36 feet (current channel depth). By taking into account Figure 10 above and Figure 11 below one can see the potential to gain efficiencies in operations by loading some of the current vessels calling on the port more heavily. 44 vessels is a conservative number (i.e. one which understates the number of vessel calls restricted by channel depths) due to the fact that this simplistic observation did not account for the under keel clearance requirement of the vessels. Accounting for the under keel clearance would increase the number of vessels that may potentially gain from a deeper channel. The terms ‘vessel transit’ and ‘vessel call’ appear throughout the tables and the text of the entire report. For purposes of this report a transit can be interpreted as an individual arrival or departure, and a call can be interpreted as a cycle (arrival and departure).

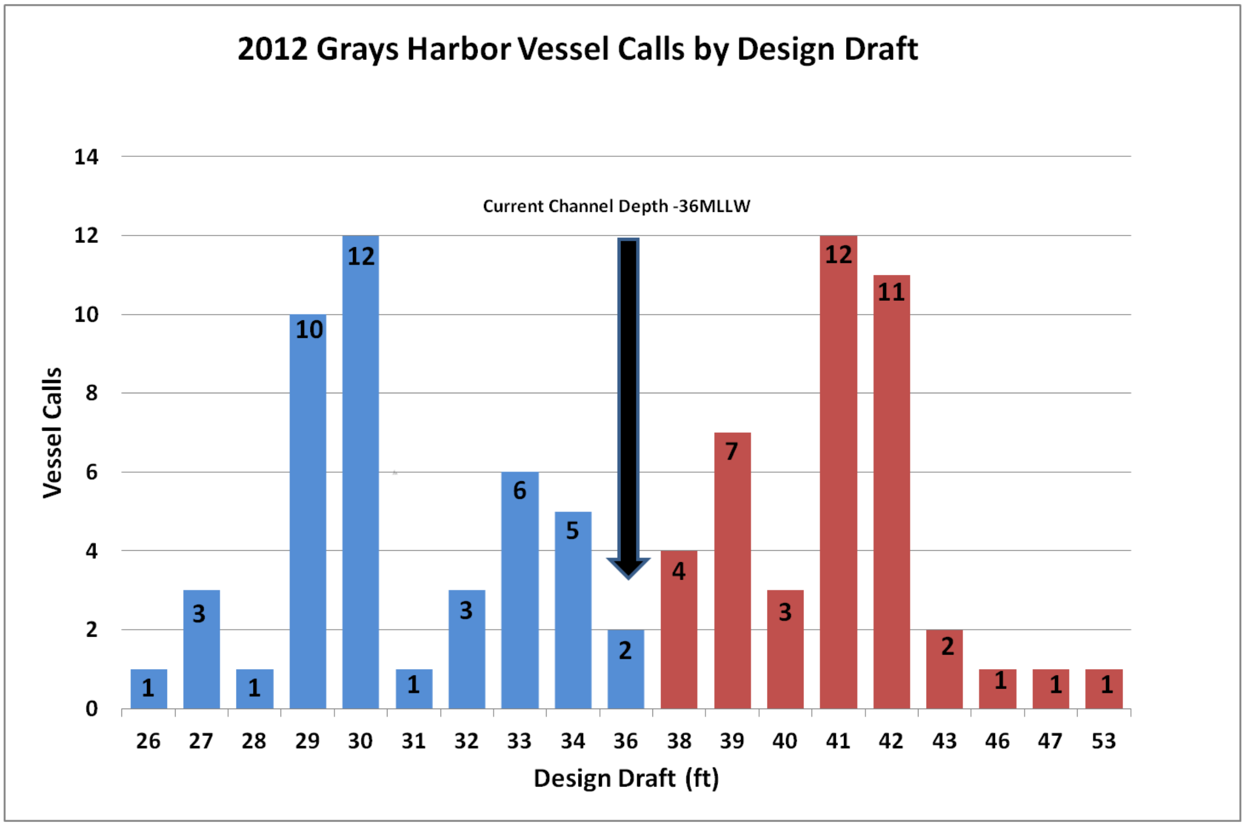

Figure 11: 2012 Port of Grays Harbor Vessel Calls by Design Draft

3.2 Environmental Existing Conditions (Affected Environment)

Existing conditions (affected environment) pertinent to each resource area are described to inform the consideration of environmental consequences and the potential significance of the recommended plan on these resources. Table 15 summarizes the affected environment for each resource area. The SEIS describes each resource area in detail (Appendix C of this LRR).

Table 15: Summary of Affected Environment

Resource	Characteristics of the Affected Environment
Marine Transportation	A variety of commercial, recreational, and Tribal vessels use the navigation channel to transit through the area, including the use of four terminals at the Port of Grays Harbor adjacent to the Hoquiam and Cow Point reaches.
Geomorphology	The morphology of the harbor is determined by differences in the capacity of harbor inflows (flood currents) and waves to transport sediment into the harbor and outflows (ebb currents) to transport sediment out of the harbor. Grays Harbor is generally dominated by tidal currents, but high flows on the Chehalis River can influence currents in the upper estuary, and the locations of shoals continually shift. Sediment transport is influenced by the complex dynamics of fluvial sediment and water inputs from tributaries entering the harbor and mixing with marine sediment and water inputs from the Pacific Ocean. Historic changes to the estuary, as a result of many factors, including but not limited to the presence of the navigation channel, jetties, and the Point Chehalis Revetment, have altered the natural geomorphology of Grays Harbor.

Resource	Characteristics of the Affected Environment
Aquatic and Terrestrial Vegetation	With the exception of the inner harbor shoreline near the Port terminals, Grays Harbor is relatively undeveloped and contains many intertidal mudflats, eelgrass meadows, large areas of intertidal salt marsh, and sand dunes stabilized by dunegrass. However, the water depths, currents, and shifting sediments within the navigation channel and placement sites do not support these types of habitats.
Invertebrates, Fish, and Wildlife	Numerous economically, culturally, and ecologically important invertebrate, fish, and wildlife species rear, migrate, and/or reproduce in Grays Harbor and adjacent nearshore marine areas. Dungeness crab, numerous clam species, oysters, and a diverse epibenthic community provide forage for the fish, birds, and other wildlife. A variety of groundfish, forage fish, and other fish species can be found there, including six species of salmon, green sturgeon, and white sturgeon. The Grays Harbor National Wildlife Refuge and the expansive mud and sand tidal flats of Grays Harbor provide habitat to as many as 278 species of birds, while the Harbor waters are known to support a variety of marine mammals, such as harbor porpoises and harbor seals. Larger marine mammals such as killer whales and several species of sea turtle are known to occur in Washington waters outside of the harbor.
Threatened and Endangered Species	Twenty-two species of federally listed threatened and endangered species may potentially occur in the vicinity of Grays Harbor and its surrounding shoreline and nearshore area. These species include 4 birds, 6 fish, 6 marine mammals, 4 sea turtles, and one terrestrial butterfly. Most of these species are not known to occur in the navigation channel or near the dredged material placement sites. The species most likely to occur within the vicinity of the proposed action are the Pacific salmon species (Lower Columbia River Chinook salmon, Upper Willamette River Chinook salmon and Columbia River chum salmon), bull trout, eulachon, green sturgeon, marbled murrelet, western snowy plover, streaked horn lark, and killer whale.
Historic and Cultural Resources	There are no cultural or historic resources in the area of potential effect of the proposed action. There are two known cultural resources sites located in Grays Harbor, neither of which is located in the navigation channel. Six archaeological sites have been identified either within 1 mile of the area of potential effect or during previous Corps cultural investigations for other elements of the Grays Harbor and Chehalis River Navigation Project, but none are within the navigation channel or dredged material placement sites.

Resource	Characteristics of the Affected Environment
Water Quality and Sediment Characterization	The history of industrial uses in and around Grays Harbor, its shoreline, and nearshore environment have led to significant past water quality problems for the Chehalis River and inner harbor near Hoquiam and Aberdeen and create the potential for contaminated sediments in the navigation channel. Sediment testing is conducted prior to dredging and the Dredged Material Management Program (DMMP) agencies review dredging and placement of material to ensure appropriate methods of sediment removal and placement (or disposal if warranted) are followed based on the composition of the sediments and their potential for impacts on aquatic organisms. Three out of four of the South Reach dredged material management units (DMMU) did not meet the exclusionary criteria and required contaminant testing. None of the DMMUs exceeded the dioxin limits for disposal in Grays Harbor. Cow Point DMMU subunit 32a was found to be unsuitable for open-water disposal due to toxicity expressed in sediment larval bioassay. The waters of Grays Harbor generally meet state water quality standards with the exception of one testing site near the harbor entrance that has in the past (2008) been identified as having intermittently low dissolved oxygen levels. Past issues (1999) with fecal coliform bacteria pollution in the inner and outer harbor have been resolved and fecal coliform bacteria pollution is no longer a problem.
Air Quality, Noise, and Artificial Lighting	The ambient air quality in Grays Harbor is generally good; potential sources of particulates include local automobiles, local fishing vessels, a local pulp mill, and ocean-going commercial cargo vessels. Noise and sources of artificial lighting in Grays Harbor are minimal and are primarily associated with the populated cities of Westport, Aberdeen, Hoquiam, and Cosmopolis. Sources of noise on the water include vessel traffic, and small private and port-related operations on the shoreline in the eastern portion of Grays Harbor. Sources of artificial lighting in the vicinity of the navigation channel and the placement sites include vessel traffic in the navigation channel, private homes, small private marinas and docks along the shoreline (particularly along Point Chehalis) and port-related operations along the eastern shoreline of the Cow Point and Hoquiam reaches of the navigation channel.
Land Use and Aesthetics	Development including commercial, residential, transportation, and communications/utilities land uses are more concentrated on the eastern and western sides of the harbor in the cities of Westport, Aberdeen, Hoquiam, and Cosmopolis. Undeveloped land and resource production land uses are prevalent along the northern and southern margins. Grays Harbor also encompasses many recreational areas, including several state and local parks and designated wildlife areas. The viewshed for Grays Harbor is quite large, extending more than 10 miles from east to west. The harbor is a wide, long estuary with low, forested hills around the bay on the north, east, and south sides. Views around this area are panoramic, extending across the estuary to the horizon. Only distant landforms and color contrasts are visible across the long distances of the Grays Harbor viewshed.
Recreation	Grays Harbor hosts a large array of recreational opportunities including fishing, clamming, crabbing, birding, wildlife viewing, surfing, hunting, hiking, picnicking, and recreational boating.

Resource	Characteristics of the Affected Environment
Global Climate Change	Statewide emissions in 2008 were 101.1 million metric tons of carbon dioxide equivalent (CO2e) (approximately 2% of nationwide emissions). The following changes are expected to occur along the Washington coast as a result of climate change: inundation, flooding, erosion and landslides, saltwater intrusion, and increased ocean surface temperature and acidity. Sea level rise and changes in sediment transport into Grays Harbor may alter the need for maintenance dredging in the future, but the complexities of sediment transport make the degree and nature of such changes unknown at this time.
Local Economy / Socioeconomics	The economies of the cities immediately surrounding Grays Harbor are linked to the import and export of goods through the Port of Grays Harbor and recreational, Tribal, and commercial use of the harbor's aquatic resources. The economy of the larger Grays Harbor County centers on natural resources, including the timber industry (particularly silviculture, logging and forest product manufacturing) and fisheries (commercial and recreational fishing, shellfish and fish processing). The recent recession impacted Grays Harbor County in terms of loss of employment and wage income. The unemployment rate in Grays Harbor County remains significantly higher than the statewide average.
Environmental Justice Communities	Grays Harbor County had a population of 76,797 (2010 census data). The populations of surrounding towns (Westport, Cosmopolis, Hoquiam, and Aberdeen) range from a high of 16,986 in Aberdeen to 1,649 in Cosmopolis. The county (88.3%) and the communities near the proposed action are predominantly white (80% of residents). The largest numbers of residents identifying themselves as American Indian/Alaska Native or Hispanic or Latino reside in Hoquiam and Aberdeen. Unemployment is considered high in Grays Harbor County (11.6%), as well as in the surrounding towns of Westport (14%), Hoquiam (12.3%), Cosmopolis (4.1%) and Aberdeen (10.1%). Unemployment rates also vary between ethnicities in each town, with Hispanic or Latino residents of Hoquiam having the highest unemployment rate of 27.6%.
Indian Treaty Rights	Native American tribes that may be affected by the proposed action include the Quinault Indian Nation, the Chehalis Indian Tribe, and the Shoalwater Bay Indians. Only the Quinault Indian Nation has a reservation and federally adjudicated off-reservation hunting and gathering rights to locations within Grays Harbor. Grays Harbor is within the federally adjudicated usual and accustomed fishing area of the Quinault Indian Nation.
Placement Site Environment	Dredged material placement would occur only at the designated placement sites that have been regularly used for material placement during the annual maintenance dredging of the navigation channel, and at the shifted Point Chehalis site. Unsuitable material would be placed upland. The South Jetty placement site is a public, multi-user, unconfined, open-water dredged material placement site managed by Washington State Department of Natural Resources (DNR); the shifted Point Chehalis aquatic site will also be an unconfined, dispersive, open-water dredged material placement site. Material dredged from the sandy outer reaches of the navigation channel is periodically used for nearshore nourishment at Half Moon Bay and South Beach, when those areas require material placement to offset erosion. The Point Chehalis Revetment Extension mitigation site is maintained in accordance with the October 1998 Project Inter-Agency Mitigation Agreement (see SEIS Appendix K).

4 Future without Project Conditions

The planning horizon for this project is 50 years, with a base year of 2017 and a conclusion of 2067. The base year 2017 is the first year that the project will be fully operational at the plan depths under the two action alternatives. A majority of the commodity forecasts for future conditions were taken from a Washington Public Ports Association (WPPA) and Washington State Department of Transportation (WSDOT) Marine Cargo Forecast (Associates, BST; IHS Global Insight; Mainline Management Inc., 2011). The remaining forecasts (petroleum) were taken from permit applications (Hoquiam, 2013) and other public and private sources..

The purpose of the forecast is to assess the expected flow of waterborne cargo through Washington's port system and to evaluate the distribution of cargo through the state's transportation network, including waterways, rail lines, roads, and pipelines. For this study, the forecasts were applied to existing conditions (2012) through 2037, at which point the forecasts were held constant from 2037 through 2067. The WSDOT Cargo Forecast forecasts to 2030, whereas the forecasts used for the economic analysis took the forecast out to 2037, and then assumed commodity growth would level off because of the difficulty accurately forecasting farther out in time. This is a small extension of the forecast as the commodity growth percentages ranged from .2% to 3.9% and was done for the ease of analysis with respect to the HarborSym modeling suite. This additional extension in forecast years is not expected to change the outcome of the NED selected plan.

The reason the forecasts were held constant after 2037 is that forecasting tends to become less accurate when attempting to predict future conditions further out in time. The level of uncertainty increases as time elapses and it becomes more difficult to give an accurate estimate more than 20 years into the future. In addition, the marine cargo forecasts display a moderate-growth and high-growth forecast growth percentage. A moderate-growth percentage was applied to the commodity growth rates for the Port to ensure conservative projections were used throughout the economic analysis (See Appendix A, Economic Analysis, for details of this analysis.)

As with any forecast, growth forecasts have some associated uncertainty and are only used to help make an informed decision for planning purposes. The use of linear forecasts was applied but the true nature of economic markets is anything but linear. The general idea is that in the short run markets act erratic but in the long term the peaks and troughs are less sharp with respect to the extensive time horizon.

The growth estimates are conservative and are relatively accurate based on the observation that the WSDOT Cargo Forecasts have generally been accurate predictions of future growth. In addition, growth is expected to follow the forecast throughout the project life independent of implementation of a deepening project. A major concern at the Corps is to avoid basing a project's benefits on business that is not presently at the project location. The concern is to avoid improperly justifying a project on the supposition that if the channel is deepened, the business will come. The Port of Grays Harbor has enough current business to justify the project and additional business from outside the periphery of the project is not expected to present itself. There is no indication that new products, other than petroleum, or additional cargo beyond what has been analyzed to date which included petroleum, is expected to present itself even with a channel deepened for -38 feet MLLW, based on the information drawn from regional reports, the niche markets (non containerized cargo) the Port of Grays Harbor is now operating in, and Port feedback.

4.1 Future Commodity Movements

Economic growth in the Port's principal trade partners – China and the Philippines – is expected to result in increased demand for goods exported from Grays Harbor. Growth in the volume of commodities moving through the Port is also expected. Future Port commodity growth for the 50-year planning horizon from the base year of 2017 to 2067 is summarized in Table 16 and shown graphically in Figure 12. Note that all commodity projections used the moderate growth forecast derived from the WSDOT Marine Cargo Forecast (Associates, BST; IHS Global Insight; Mainline Management Inc., 2011). Much of the source of the petroleum projections were taken from direct contact with the entities proposing to move crude through Grays Harbor or from permits submitted by the aforementioned entities and the administrative records generated by the evaluation of those requests.

Table 16: Port of Grays Harbor Commodity Moderate Growth Projections (2017-2067)

Port of Grays Harbor Commodity Growth Projections (2017-2067)							
Commodity	**2017**	**2027**	**2037**	**2047**	**2057**	**2067**	**CAGR (2017-2037)**
Petroleum Moderate	8,467,922	8,638,812	8,813,152	8,813,152	8,813,152	8,813,152	0.2%
Chemicals Moderate	130,726	252,392	487,290	487,290	487,290	487,290	6.8%
Forest Products Moderate	267,290	301,153	339,307	339,307	339,307	339,307	1.2%
Food & Farm Products Moderate	1,445,873	1,550,332	1,662,339	1,662,339	1,662,339	1,662,339	0.7%
Manufactured Equipment Moderate	191,913	281,358	412,492	412,492	412,492	412,492	3.9%
Total Commodities Moderate	10,503,723	11,024,048	11,714,580	11,714,580	11,714,580	11,714,580	0.55%

Growth in cargo tonnage at the Port, for purposes of this 50-year analysis, is expected to be similar between the future with-project and future without-project conditions. This projected parity in cargo growth curves is primarily due to the extrinsic limitations on Port of Grays Harbor capacity that restrict the opportunity for cargo throughput. Given the existing facilities at the Port, predicted future growth under a future with- or without-project scenario will reach maximum capacity at an estimated 469 vessel calls/year based on the following calculation of an average vessel moving a set average tonnage:

- Terminal 1. Liquid bulks. Average days at berth = 3. 365/3 = 122 vessel calls
- Terminal 2. Agricultural dry bulk. Average days at berth = 5. 365/5 = 73 vessel calls
- Terminal 3. Breakbulk logs. Average days at berth = 6. 365/6 = 61
- Terminal 4A. Auto RORO. Average days at berth = 3. 365/3 = 122 vessel calls
- Terminal 4B. Breakbulk. Average days at berth = 4. 365/4 = 91 vessel calls

Vessel calls and, therefore, cargo capacity are limited by a number of terminal capacity factors including berthing space (number of berths at the Port), berthing depth (-42' MLLW), terminal space for cargo storage and re-handling, and intermodal capacity for delivery by rail of cargo for export, and are further limited by channel width under current channel maintenance conditions limiting concurrent two-way transit in the inner harbor. Per the Port's Executive Director, the Port does not currently have designs or funding in place to make major facility improvements that would facilitate expansion to support growth beyond that estimated maximum of 469 vessels per year. Similarly, the HarborSym modeling is showing vessel calls per year reaching a maximum at 491. The system starts deleting vessels in the later years at a higher rate possibly indicating a maximum threshold on par with the Port's estimated number of 469 vessels. This projected parity in growth expectations between with- and without-project conditions reflects an economically conservative perspective that reduces the likelihood of overstating the economic benefits of project implementation. Note that the SEIS takes a differing approach, and from an environmentally conservative point of view that NEPA document projects a greater increment of growth in cargo throughput under the future with-project condition than under the future without-project condition.

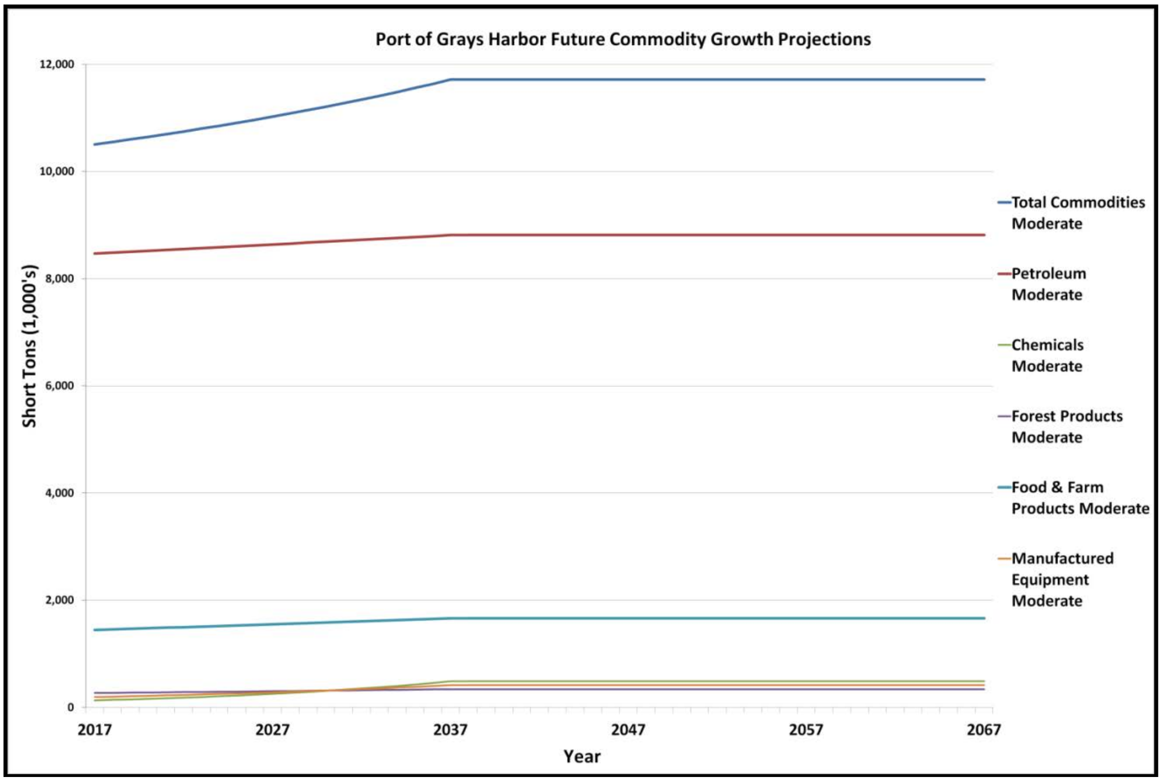

Figure 12: Port of Grays Harbor Commodity Growth Projections

Petroleum: The Port is expected to move crude oil by rail (CBR) in the near term (2-5 years), independent of project implementation. There are three proposed CBR projects at the Port of Grays Harbor. The crude oil would travel to the Port from a variety of locations in the U.S.; the most likely source would be the Bakken Shale in North Dakota and Montana.

For purposes of this economic analysis, all three proposals are assumed to move forward by late 2014 with a brief ramp up period from 2015 through 2017. For purposes of benefit analysis and modeling purpose the ATB's (design draft of 28 feet) and the petroleum (approximately 50% of total petroleum tonnage) associated with them were taken out of the modeling used in the BCR but will be included in the SEIS. The total number of vessels needed to move all crude, to include the aforementioned removal of ATB's, will still be displayed in the total vessel count that is expected to call on the Port (Table 14). Because these vessels are not draft constrained they are excluded from the modeling that informs the benefit-cost analysis used to justify the project.

As of May 2014, permits have been submitted and a Mitigated Determination of Non-Significance was issued by the City of Hoquiam and the Washington Department of Ecology for the Westway Terminal Company. A Mitigated Determination of Non-Significance was issued and the Shoreline Substantial Development Permit was issued in June of 2013 for the Imperium Terminal Services, LCC. The third proposal by Grays Harbor Rail Terminal (US Development Group) has been granted the Option to Lease Terminal 3 by the Port Commission for an additional 24 months to allow for further analysis and additional time to obtain permits to bring their proposed project to shovel ready status. The project status of the proposed crude oil facilities are as follows:

Westway Terminal Company
January 2014, self-initiated Environmental Impact Statement (EIS) for proposed project.

Imperium Terminal Services, LLC
January 2014, self-initiated Environmental Impact Statement (EIS) for proposed project.

Grays Harbor Rail Terminal (US Development)
April 2014, permit applications and SEPA checklist submitted to City of Hoquiam.

After 2017 the growth of petroleum exports at the Port are expected to follow the commodity projections from the WSDOT Marine Cargo Forecast of approximately .2% per year. After 2037 the growth projections are to be held constant based on the assumption that as time elapses the projections become less accurate due to uncertainty in what the future conditions may be (Figure 13).

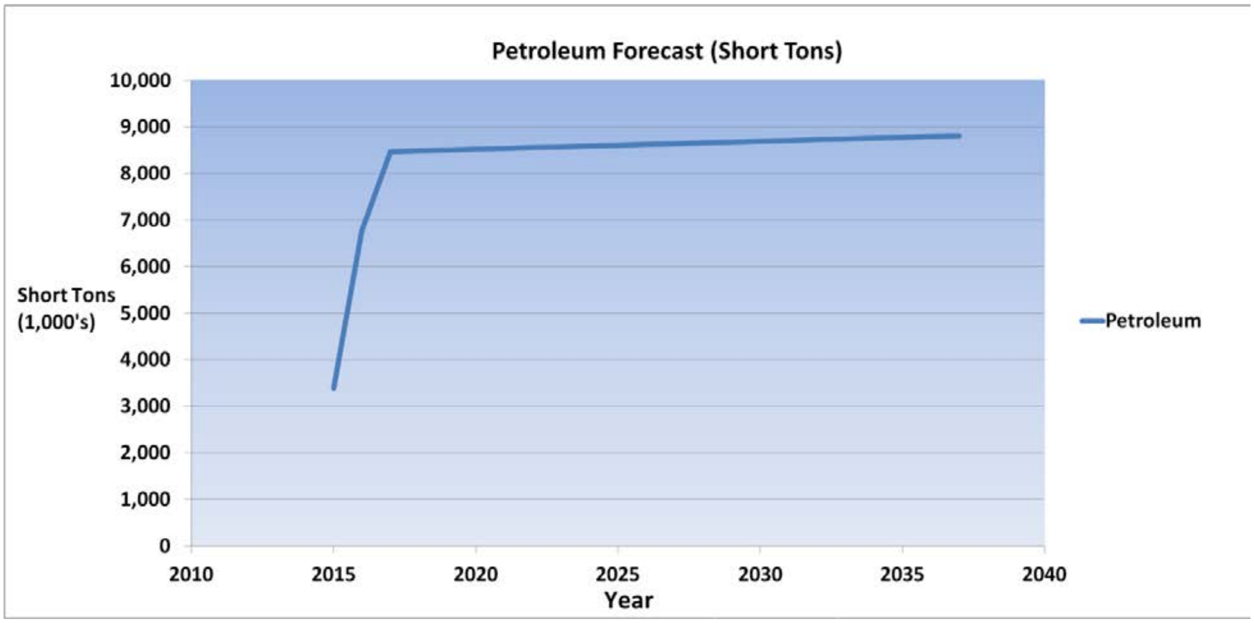

Figure 13: Petroleum Forecast

Soybean: In 2012, a record setting 1.69 million metric tons of soybean products were exported through the Port to China, Japan, Philippines, Indonesia, Vietnam, and Australia. The category Food and Farm Products was used to consolidate grain, oilseed and soybean into one category. In the base year 2017 the category Food and Farm Products, under the moderate growth assumption, is expected to be approximately 1.4 million short tons and have a CAGR of 0.7%.

Forest Products: The Port historically relied heavily on lumber and forest products to sustain business. Demand shifted to less costly sources two decades ago. While forest products remain an important piece of the Grays Harbor cargo mix, the Port has substantially diversified the products shipped to include automobiles, biodiesel and other liquid and dry bulk products. Tonnage and demand are expected to increase due to the U.S. housing market recovery. The moderate growth forecast for Forest Products is expected to increase approximately 1.2% in the next 30 years.

Manufactured Equipment (Vehicles): The Port has become a major exporter of domestically produced Chrysler and Jeep vehicles. This began with the signing of a 20 year lease agreement with Pasha Automotive Services in 2009, an automotive exporter based in California, and has since increased year after year. Pasha shipped approximately 71,000 Chrysler vehicles in 2012 and expects to export approximately 100,000 in 2013 (Wilhelm, 2013).

The vehicles, along with manufactured heavy equipment, are exported to Asia (China, Japan, and South Korea). The vehicles arrive by rail and are loaded on Roll-on Roll-off vessels at Terminal 4. According to the WSDOT Marine Cargo Forecast, fully assembled autos will exhibit rapid growth with a moderate CAGR of approximately 3.9% and a high CAGR of approximately 4.9%. The moderate CAGR of 3.9% was used for the economic analysis and was taken out 20 years (2017-2037) at which point the growth was assumed to remain at zero.

4.2 Future without Project Vessel Movements

The increased volume in commodities moved through the Port during the 50-year period of analysis described above is expected to be enabled by an increase in the number of vessels over the same period. This increase in vessel traffic anticipated over time would not be caused by the deepening action, because channel dimensions are not a present or expected limiting factor on cargo growth, and the vessel traffic increase is expected to occur independent of the deepening because of the growth in commodity volume. Thus, cargo tonnage and numbers of vessel transits are both expected to grow, under both the future without-project condition and the future with-project condition. As described in Section 4.1, the volume of cargo throughput in each year over the 50-year period of analysis under the future without-project condition is expected to be the same as the cargo volume in the corresponding year under the future with-project condition.

In addition, the future without project vessel origin and destination are expected to be the same, and the overall size and type of vessels will remain relatively unchanged regardless of whether a deepening project is implemented. The future without project condition is defined as without further deepening – i.e. currently implemented and maintained project of -36 feet MLLW.

The independent commodity growth estimates were mostly derived from the Washington State Marine Cargo forecast (Associates, BST; IHS Global Insight; Mainline Management Inc., 2011). These commodity growth forecasts were applied to the Port of Grays Harbor's existing commodities to get an aggregate tonnage expected to move through the Port during the 50 year life of the project. For purposes of this economic analysis, a conservative approach is taken utilizing this source's moderate growth projections, to reduce the possibility of overstating the economic benefits of project implementation. Note that, by contrast, different growth projections are used in the SEIS: in that NEPA document, optimistic economic growth projections are used to form the basis for evaluating the environmental consequences of the preferred alternative. The SEIS's environmentally conservative approach reduces the possibility of understating the potential effects of project implementation on the quality of the human environment for purposes of NEPA analysis. The total tonnage and commodity types were used to put together a fleet forecast using the Bulk Loader Tool to calculate the number of vessels needed to satisfy the commodity demand at the Port. The Bulk Loader Tool is an integrated module within HarborSym designed to generate synthetic vessel call lists based upon user provided calling statistics. These statistics include information on tonnage, commodity type, and vessel characteristics. The independent commodity growth estimates are expected to be adhered to during the project. That is to say that growth estimates above and beyond what is in the independent commodity estimates or from other sources are not expected to occur. In addition, the total vessels needed to move the specific cargo during the project life is expected to be at its highest under the without-project condition (i.e. Alternative 1), and see a decline in the number of vessels needed to move the same amount of cargo due to efficiencies attributed to the implementation of the project (i.e. Alternative 2 or Alternative 3). Because an economically conservative moderate growth projection is used here for economic analysis purposes, while an environmentally conservative optimistic growth projection is used in the SEIS for environmental effects analysis purposes, the projection of future with-project condition vessel movements under Alternative 3 will be different in the SEIS.

5 Alternative Plans

As noted above, the scope of this feasibility study is limited to evaluating the following three alternatives. Each of the three alternatives also includes advance maintenance and allowable overdepth dredging[2].

5.1 Alternative 1: No Action (Continue Channel Maintenance to -36 Feet MLLW)

Section 1502.14 of the Council on Environmental Quality regulations implementing NEPA (42 United States Code [USC] 4371, et seq.) requires that the environmental review sharply define the issues and provide a clear basis for choice among options by the decision makers and the public. To comply with this requirement, NEPA regulations require that the review include a no-action alternative to ensure that impacts associated with taking no action are compared to the effects associated with a reasonable range of alternative ways of accomplishing a project's purpose and need.

Where ongoing programs initiated under existing legislation and regulations would continue, 'no action' may be defined as no change from current management direction or level of management intensity (Council on Environmental Quality 1981). Therefore, the No Action Alternative may be thought of in terms of continuing with the current course of action until that action is changed. Accordingly, projected effects of the alternatives would be compared to those effects projected for current practices.

The No Action Alternative provides the baseline conditions for comparing the potential effects of the two action alternatives. Under Alternative 1, the No Action Alternative, the Corps would continue the current practice of maintenance dredging of the navigation channel to a depth of −36 feet MLLW and placement of the dredged materials at a variety of open-water placement, beach nourishment, and upland beneficial use sites, as described below. It is important to note that under Alternative 1 the navigation channel would be maintained in its existing condition, and tidal delays and light loading of ships would continue. Alternative 1 does not meet the planning objectives described in Section 1.11, but is carried forward in this analysis for the purpose of comparing the relative merits and disadvantages of the action alternatives.

[2] *Advance maintenance* is dredging to a specified depth and/or width beyond the authorized channel dimensions (Figure 2-1) in critical and fast-shoaling areas. Where justified, advance maintenance typically occurs during each periodic episode of maintenance dredging. Advance maintenance allows the Corps to avoid frequent re-dredging, and ensures the reliability and least overall cost of maintaining channels to authorized and implemented dimensions (U.S. Army Corps of Engineers 2006). To assure channel operational reliability and least overall cost, the Corps allows an additional 2 feet of depth in the applicable reaches of the Grays Harbor navigation channel prism.
Allowable overdepth is dredging to a permitted depth and/or width outside the required channel prism to allow for the inherent inaccuracies in the dredging process. During typical dredging activities, precision varies with physical conditions, dredged material characteristics, channel design, and type of dredging equipment used. Due to these variables and the resulting imprecision associated with the dredging, the Corps recognizes that dredging below the authorized dimensions occurs. To compensate for these inevitable inaccuracies, the Corps allows for a maximum overdepth tolerance of 2 feet beyond the advance maintenance depth (U.S. Army Corps of Engineers 1996)

The No Action Alternative in this analysis is continued Operations and Maintenance dredging to -36 feet MLLW for the reaches addressed in this SEIS (South Reach, Outer Cross-over, Inner Cross-over, North Channel, Hoquiam, Cow Point and Cow Point turning basin). The full analysis of the No Action Alternative is described as part of the Fiscal Years 2012 through 2018 Maintenance Dredging and Disposal, Grays Harbor and Chehalis River Navigation Project Environmental Assessment, dated September 2011 (Corps 2011) as supplemented in 2013 (Corps 2013; 2014). The 2011 maintenance dredging environmental assessment (EA) evaluated the impacts of dredging the maximum expected volume in any given year to meet the -36 ft MLLW depth (see table 13 for volume estimates) for the full channel (Entrance to Aberdeen reaches). However, the deepening reaches (South Reach to Cow Point) are the only pertinent areas for purposes of this feasibility study. The actual volume dredged for any reach is dependent on sedimentation rates and available funding during that maintenance dredging year, and would likely be less than the volumes estimated in the 2011 maintenance dredging EA in most years. Since promulgation of the 2011 EA, the Corps has implemented a minor realignment of the navigation channel in discrete locations. This modification is intended to take advantage of greater scour from river and tidal currents, which is expected to reduce the volume of material accumulating in these portions of the navigation channel. This modification is also projected to significantly reduce future dredging in this portion of the navigation channel, which would, in turn, avoid and reduce impacts of dredging and disposal. This channel realignment was evaluated in a 2014 Supplemental Information Report to the 2011 maintenance dredging EA, and the Corps concluded that formal supplementation of the EA was not necessary in that context . The estimated dredge volumes presented here and environmental evaluation of potential effects of channel deepening in the SEIS take into account this implementation of the minor channel alignment modification, that is part of the continuing maintenance to -36 feet MLLW (Alternative 1).

5.1.1 Maintenance Dredging Process

The Grays Harbor navigation channel is divided into discrete reaches, which are based on physical characteristics and dredging requirements. These include five “inner harbor” reaches (Aberdeen, Cow Point, Hoquiam, North Channel, and Inner Crossover) (Figure 2 in Chapter 1) and five “outer harbor” reaches (Outer Crossover, South, Point Chehalis, Entrance Channel, and Bar Channel) (Figure 3 of Chapter 1). Under Alternative 1 the reaches evaluated in this study, those segments from South Reach to Cow Point would continue to be dredged in order to maintain a depth of −36 feet MLLW.

5.1.2 Dredging Schedule

The dredging schedule varies by reach (Table 17). Dredging occurs between July 16 and February 14 in the Cow Point turning basin, Cow Point, and Hoquiam Reaches, and from 1 August to 14 February in the North Channel and Inner Crossover Reaches. Dredging is scheduled to allow removal of shoals resulting from high river flows in the spring and to avoid salmonid migrations in the spring and early summer. Typically, this dredging operation lasts approximately 4.5 months but could be up to an allowed window of 6 months, depending largely on weather conditions. For the outer harbor reaches, dredging occurs between April 1 and June 30 in South Reach, and the Outer Crossover is dredged 1 April to 31 May if a hopper dredge is utilized or 1 August to 14 February if a clamshell dredge is used. The duration of maintenance dredging in these outer harbor reaches can vary year to year, but is typically about 1 month. Dredging is scheduled for this time to coincide with favorable weather/wave conditions and to reduce impacts on the Dungeness crab fishery. Therefore, throughout the year dredging and placement of dredged materials are not occurring during two periods: February 15 through March 31 and July 1 through July 15.

5.1.3 Dredging Methods and Equipment

The Corps uses two methods to dredge the navigation channel. The first method is a mechanical or "clamshell" dredge, which is used to dredge the inner harbor reaches (including the entire Crossover reach, however, a hopper dredge may still be used in the Outer Crossover reach when necessary). Clamshell dredges include use of a tugboat and two barges, one to support the clamshell derrick and the other a bottom-dump barge for storage and transport of the dredged material to the placement site. Under baseline conditions (Alternative 1), one tugboat is used to position one clamshell dredge (on a barge) and one bottom-dump barge is used to transport material in order to complete the inner harbor dredging.

Use of a clamshell dredge has been well documented to greatly reduce both entrainment and mortality of crab and other aquatic species when compared to a hopper dredge (Armstrong et al 1987, Dumbauld et. al. 1988). Clamshell dredging is used exclusively in the Inner reaches (inner Cross-Over Reach and inward) to reduce entrainment of fish, shrimp, and crabs in the inner harbor reaches. For the outer half of the Cross-over Reach clamshell use is emphasized and preferred, however this reach can be dredged with either hopper dredge or clamshell. The clamshell bucket proceeds from the outer edges of the navigation channel, across the channel to the other bank and then back, dredging progressively until the desired depth is achieved. This method of dredging, along with the mild angle of the channel's side slopes (e.g., 1V:5H in South Reach, steepening to 1V:3H beginning at the North Channel), leaves the channel width substantially unchanged and minimizes the potential for sloughing/avalanching of sediment from the channel's side slopes after dredging is completed.

The other method uses a hydraulic hopper dredge for the reaches in the outer harbor. The hopper dredge is able to dredge material, store it onboard, transport it to a placement area, and deposit it. Two government hopper dredges "Essayons" and "Yaquina" have annual assignments in Grays Harbor to perform outer harbor maintenance dredging. Hopper dredges are better suited for use in the more exposed outer harbor reaches, because clamshell dredges must be rafted together with a scow barge, which can be hazardous in choppy seas. Sediments removed from the outer harbor reaches are primarily sands of marine origin that are extracted using a hopper dredge. These heavy particles settle out of suspension rapidly and generally do not disperse to adjacent areas (U.S. Army Corps of Engineers 2011). Use of a hopper dredge also reduces suspension of these heavier sediments.

The hydraulic hopper dredge typically cuts from the toe of the sideslope outward, maximizing the bank height to achieve greater production rates. The mild angle of the channel's side slopes minimizes the potential for sloughing/avalanching of sediment from the side slopes after dredging is completed.

5.1.4 Annual Maximum Volume of Dredged Material

The 2011 maintenance dredging EA evaluated the impacts of dredging the maximum expected volume in any given year to meet the -36 ft MLLW depth. Currently, the Corps removes an annual maximum volume of approximately 2.09 million cubic yards in the six reaches targeted for deepening (South, Outer Cross-over, Inner Cross-over, North Channel, Hoquiam, and Cow Point Reaches, including the Cow Point Turning Basin) annually to maintain the channel depth at -36 feet MLLW in these reaches. An annual maximum volume of approximately 1.66 million cubic yards is removed from the inner harbor reaches (Inner Cross-over, North Channel, Hoquiam, Cow Point Reaches and Cow Point turning basin) and an annual maximum volume of approximately 425,000 cubic yards is removed from the outer harbor reaches (South and Outer Cross-over Reaches).

Table 17 lists the annual maximum volume of material dredged from each reach of the navigation channel under baseline conditions (Alternative 1) to maintain the channel at a depth of −36 feet MLLW, the characteristics of the reaches, and the typically allowed timing of dredging activities for each reach. The volumes in Table 17 include one standard deviation and include both Advance Maintenance and Allowable Overdepth quantities (described above), and have been computed by the Corps based on 10 years of Grays Harbor dredging records from 2000 to 2010. The actual volume dredged in any one year varies from these averages based on volume deposited, location and extent of targeted shoals, and Congressional funding, which dictates the duration/amount of dredging that can be executed in a particular year.

Table 17 also includes the dredged material placement sites that are typically used for material from each reach. The actual placement site utilized during dredging is determined as described in Section 5.1.5 (Dredged Material Placement). The dredged material is deposited at approved designated areas, including the Point Chehalis and South Jetty open-water placement sites. Dredged material is also deposited at nearshore locations at Half Moon Bay and South Beach—where the material provides a beneficial use (i.e., beach replenishment). Details regarding the dredged material placement sites are presented below in Section 5.1.5.1 (Dredged Material Placement Sites).

Table 17: Reach Characteristics of the Grays Harbor Navigation Channel at -36 feet MLLW

Reach	Approximate Average Volume (cubic yards)[a]	Sediment Type	Dredge Type	Channel Dimension[b] (feet) (MLLW/ wide)	Placement Site	Work Closure	Work Schedule
Cow Point	750,000 annually	Sandy silt	Clamshell	−36/350–550	South Jetty or Point Chehalis[c]	Feb 15–July 15	July 16–Feb 14
Cow Point Turning Basin	215,000 annually	Sandy silt	Clamshell	−36/350–950	South Jetty or Point Chehalis[c]	Feb 15–July 15	July 16–Feb 14
Hoquiam	150,000 annually	Sandy silt	Clamshell	−36/350	South Jetty or Point Chehalis[c]	Feb 15–July 15	July 16–Feb 14
North Channel	175,000 annually	Silty sand	Clamshell	−36/350	Point Chehalis	Feb 15–July 31	August 1–Feb 14
Inner Crossover	375,000 annually	Silty sand	Clamshell	−36/350–450	Point Chehalis	Feb 15–July 31	August 1–Feb 14
Outer Crossover	235,000 annually	Silty sand	Hopper or Clamshell[d]	−36/350	Point Chehalis	June 1––March 31 Feb 15-July 31	April 1 –May 31 August 1-Feb 14
South Reach	190,000 annually	Sand	Hopper	−36/350–450	Point Chehalis or Half Moon Bay	July 1–March 31	April 1–June 30
Total	2,090,000 annually						

Source: U.S. Army Corps of Engineers 2011.

[a] Volumes are averages, plus one standard deviation, computed based on the last 10 years of dredging records, from 2000 to 2010 and include both allowable overdepth and advance maintenance. Thus, the actual volumes dredged in the past may be more or less than those shown in the table. These volumes are more representative of funding received rather than the volume available for dredging in the channel.

[b] Depths shown are authorized depths and do not include the 2-foot advance maintenance or 2-foot allowable overdepth. Exceptions: Aberdeen Reach has 0-foot advance maintenance and 1-foot allowable overdepth. Elliott Slough Turning Basin has a 3-foot advance maintenance for half of the channel (inside bend). Widths shown are those of the channel bottom, and do not include extra width at channel bends.

[c] Adverse weather/wave relief site.

[d] The Outer half of the Cross-Over Reach may be dredged with either hopper with work closure of June 1 –March 31: and corresponding work schedule April 1- May 30 or clamshell with closure of February 15 –July 15: corresponding work schedule of August 1 – February 14.

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5.1.5 Dredged Material Placement

5.1.5.1 Dredged Material Placement Sites

Placement of the material dredged from the navigation channel occurs only at designated placement sites. Figure 14 below illustrates the location of all dredged material placement sites for Alternative 1. Two Washington State Department of Natural Resources (DNR) public, multi-user, unconfined open-water dredged material placement sites are located directly adjacent to the navigation channel: the South Jetty and the Point Chehalis placement sites. Both sites are located on state-owned aquatic lands and managed by Washington DNR. In addition, material dredged from the sandy outer harbor reaches of the channel is periodically used for both direct upland placement at the Point Chehalis Revetment Extension mitigation site (when feasible) and nearshore nourishment at the South Beach and Half Moon Bay beneficial use sites. Material placed above mean higher high water (MHHW) in the Point Chehalis Revetment Extension mitigation site is expected to subsequently erode through natural processes, with portions of the material entering the intertidal zone and thus the littoral system. The Point Chehalis site overlaps the navigation channel however, the dispersive nature of this site effectively transports material out of the site boundaries and has historically provided sufficient capacity for annual O&M dredged material. The Southwest (also known as 3.9 mile) site has not been used for maintenance dredging.

The determination of which placement site is used during the course of maintenance dredging is based on a variety of factors. For both the inner and outer harbor reaches, placement is determined based on the source of the dredged material, the depth of each aquatic placement site, the amount of material already present at the placement sites, and weather/wave conditions at the time of placement. For the inner harbor reaches, material is typically deposited at the South Jetty site, unless there are adverse weather/wave conditions or the South Jetty site is full, in which case placement typically occurs at the Point Chehalis open water placement site. For the outer harbor reaches, some of the dredged materials may be deposited at three beneficial use sites: the Half Moon Bay site and South Beach nearshore nourishment sites, and the Point Chehalis Revetment Extension Mitigation Site. Remaining material is typically placed in the South Jetty or Point Chehalis sites. Factors that determine which placement sites are used for the outer harbor reaches include the presence of commercial crab pots in a placement site and/or access lane (for South Beach), the amount of material present (for Half Moon Bay), as surveyed annually, and results of pre-disposal Dungeness crab surveys (for both Half Moon Bay and South Beach).

The volumes of dredged material placed at each placement site over the last 12 years are summarized in Table 18.

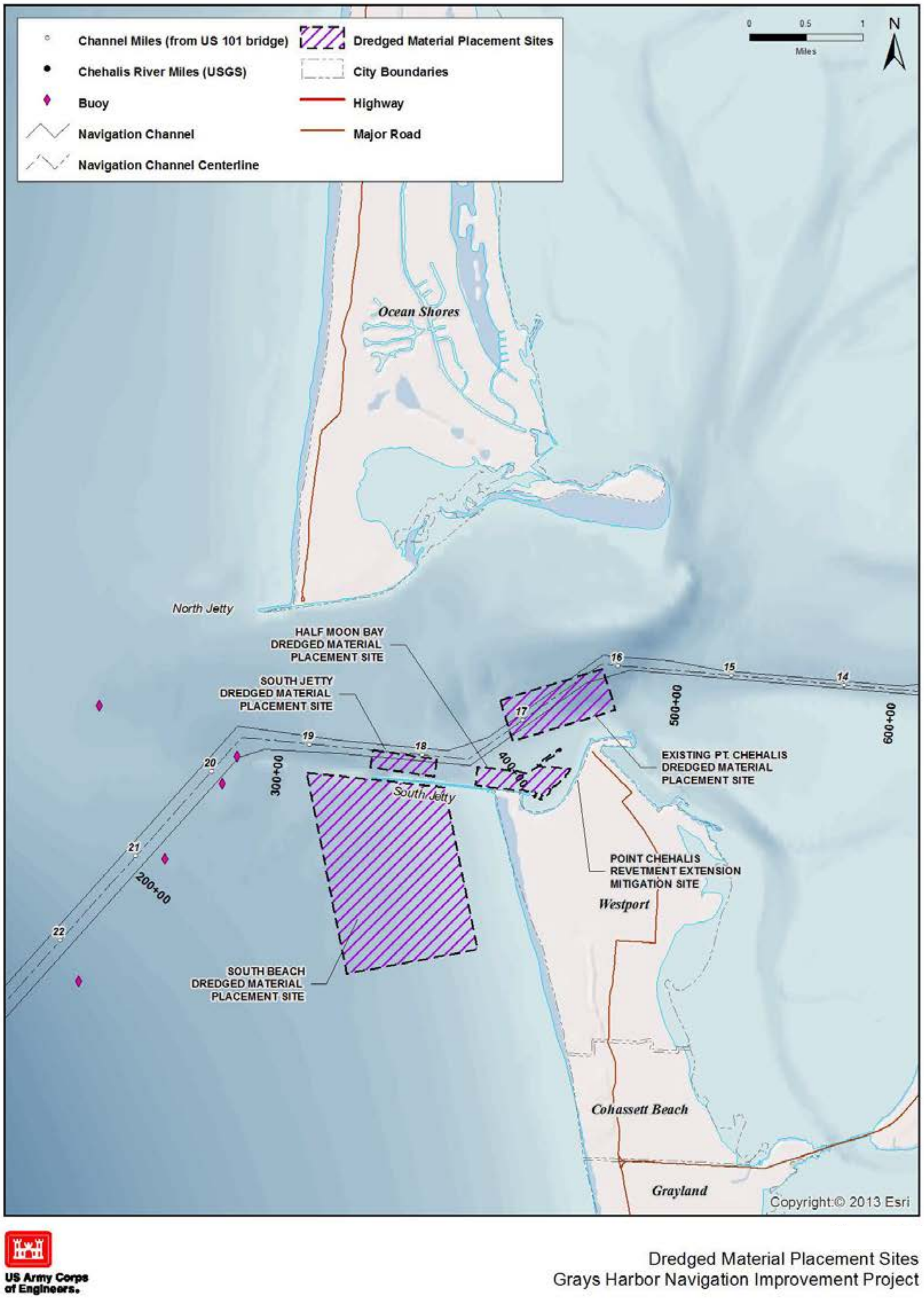

Figure 14: Open-Water Dredged Material Placement Sites for Alternative 1

Table 18: Dredged Material Deposit Volumes (cubic yards) by Placement Site for Grays Harbor at -36 feet MLLW

Year	Point Chehalis (Open-Water)	South Jetty (Open-Water)	Half Moon Bay (Nearshore)	South Beach (Nearshore)	Point Chehalis Revetment Extension Mitigation Site	Total
2000	956,700	1,200,248	0	0	0	2,156,948
2001	667,943	358,873	0	0	0	1,026,816
2002	942,310	475,199	378,441	75,219	135,705	2,006,874
2003	355,139	824,694	329,107	125,388	0	1,634,328
2004	957,186	1,166,089	289,652	262,176	0	2,675,103
2005	1,054,086	740,970	102,194	217,909	0	2,115,159
2006	1,277,837	196,833	126,892	55,170	0	1,656,732
2007	599,254	389,127	140,406	0	0	1,128,787
2008	1,288,726	707,080	171,352	0	0	2,167,158
2009	1,223,159	21,088	144,975	214,502	0	1,603,724
2010	977,282	91,720	91,720	118,182	0	1,278,904
2011	702,650	1,000,925	177,150	298,251	0	2,178,976
2012	1,481,714	320,985	111,205	142,313	0	2,056,217
Total Volume	12,483,986	7,493,831	2,063,094	1,509,110	135,705	23,685,726
Average Annual Volume (2000–2012)	960,307	576,449	158,700	116, 085	10,439	1,821,979

Source: Corps 2011 and updated for years 2011 and 2012

5.1.5.2 Dredged Material Characterization and Suitability

The types of sediment in the outer and inner harbor reaches vary, and thus their suitability for deposit at certain placement sites also varies. Materials dredged from the outer harbor reaches consist primarily of course-grained marine sands deposited by tidal action and silty sand/sandy silt redistributed in the estuary by wind and wave action. For instance, dredged material from the Bar and Entrance Channels has been found to meet the exclusionary criteria specified in the Clean Water Act (40 CFR 230.60), and thus does not require contaminant testing. This determination is based on the physical characteristics of the materials, location in a high-energy environment, and geographic separation from sources of contamination. Dredged material from these reaches is suitable for beneficial use at designated placement sites. Materials that accumulate in the inner harbor reaches originate from tributary streams and rivers. Compared to the materials in the outer harbor reaches, the inner harbor reaches contain larger fractions of fine-grained suspended/bedload sediment, and are closer to historical sources of contamination. Because of these factors, contamination testing is required prior to in-water or unconfined beneficial use placement, and subsequent testing occurs on a regular basis.

The suitability determination, prepared under the DMMP for maintenance dredging to –36 feet MLLW (i.e., Alternative 1), showed that all sediments are suitable for open-water placement. Further explanation of channel sediment suitability is provided in Sections 3.7 and 4.7 of the SEIS, *Water Quality and Sediment Characterization*, as related to the affected environment and environmental consequences, respectively.

5.1.5.3 Dredged Material Placement Method and Equipment

Dredged material is transported to open water placement sites by either a bottom-dump hopper dredge (defined above) or by a tugboat and bottom-dump (or split-hull) barge. These vessels generally have the ability to transport between 800 and 6,000 cubic yards of material each trip. The number of barge discharges per day is typically three to five, but this number varies depending on the extent of the dredging activity occurring at the time. A tug tows the barge to the open water placement site and releases the dredged material near the updrift boundary of the open water site. This allows the material to be fully released within the site boundary as currents typically result in the drift of the barge during placement. Target zones are specified annually within each open water placement site and are dependent on site capacity at the start of the dredge year. Strategic placement of dredged materials is necessary to ensure long-term site capacity and to minimize the potential for sediments to re-enter the navigation channel. Pre and post placement monitoring surveys are performed before and after placement of maintenance dredged material from the outer and inner harbor navigation channel. Some outer harbor material is typically placed at three beneficial use sites, including the South Beach nourishment site, the Half Moon Bay nearshore nourishment site, and the upland Point Chehalis Revetment Extension mitigation site. The purpose of the latter two placement sites is to maintain a stable beach profile west of the Point Chehalis revetment and to ensure that the armor stone toe of the revetment is not exposed. Sandy material is placed as close to shore as possible (nearshore nourishment), in accordance with the 1998 Point Chehalis Revetment Extension Project Inter-Agency Mitigation Agreement. Half Moon Bay is a high energy environment, subject to erosion. The nearshore nourishment site is used for material placement as bathymetric conditions permit (i.e., when the bay is deep enough for the bottom dump barge or hopper dredge to navigate). Typically the Corps uses its shallowest draft hopper dredge (MV *Yaquina*) to place material at the Half Moon Bay site. Dredged material is placed so that material will be transported, via natural processes, to the nearshore and intertidal areas to assist in maintaining existing stable beach profile.

The upland Point Chehalis Revetment Extension mitigation site was filled in 2002 with sand from the navigation channel described in the 2011 EA (Corps 2011). A hydraulic pipeline is typically used when placing outer harbor materials at the upland Point Chehalis Revetment Extension mitigation site. A hopper dredge full of a sand and water slurry docks at the existing rock dock at Firecracker Point and pumps the slurry through a pipeline to the stockpile site. Firecracker Point is a jetty extension located on the southeastern side of the southeastern entrance to the Westport Marina. Booster pumps are required to pump the slurry 1.7 miles across-town. The temporary pipeline was installed in 1994, and is buried along the road that generally crosses the Westport peninsula from Firecracker Point to Half Moon Bay. The slurry of sand and water is discharged to the area in front of the buried revetment. A sand berm/perimeter dike separates the discharge area from Half Moon Bay. The slurry of water and sand temporarily ponds in the placement site, and water is conveyed via effluent pipe into Grays Harbor at the exposed rock revetment near Groin A. A water quality monitoring plan would be implemented in accordance with an approved Water Quality Certification issued by the Washington Department of Ecology. The sandy dredged material would quickly dewater and a bulldozer would be used to grade the sand uniformly over the placement area . Material placed above MHHW in the Point Chehalis Revetment Extension mitigation site is expected to subsequently erode through natural processes, with portions of the material entering the intertidal zone and thus the littoral system.

5.2 Alternative 2: Deepen Channel to -37 Feet MLLW

Alternative 2 would implement the proposed action by deepening the navigation channel an additional one foot, compared to baseline conditions (Alternative 1), to a depth of −37 feet MLLW. Following deepening, the channel would thereafter be maintained at the new design depth of -37 feet MLLW for a period of 50 years, through annual maintenance dredging in a manner identical to Alternative 1 with the exception of a minor increase in dredged material volumes. Under this alternative the nature of the dredging would be similar to Alternative 1 with some minor modifications as further detailed in this section. Construction dredging of Alternative 2 would occur within the same dredge work window as under Alternative 1. Dredging duration would be approximately 6 months for the inner harbor reaches, or 1.5 months longer than under Alternative 1. The dredging of the outer harbor reaches would occur in the April to June work window for hopper dredging and 1 August to 14 February in Outer Cross Over Reach if a clamshell dredge is used, the same as under Alternative 1. In Cow Point Reach, dredging may require use of a barge mounted long reach excavator to rip hard substrate in the channel prior to dredging to achieve full channel depth. Previous subsurface explorations have determined sandstone exists near the upstream portion of the channel reach adjacent to Port Terminal 4. This methodology has been shown to be successful for dredging sandstone in New York Harbor. Dredged materials would be deposited at the placement sites used during maintenance dredging under baseline conditions (Half Moon Bay, South Jetty, and South Beach), and would include a shift to the Point Chehalis site and upland placement of unsuitable material.

The Corps recently completed a dredged material placement site capacity analysis for the Point Chehalis placement site to estimate short-term and long-term fate of channel deepening sediments and subsequent annual maintenance sediments that could be deposited at this site (Hayter et al. 2012). Based on sediment transport modeling and Sedflume analysis conducted (Demirbilek et al. 2010; Hayter et al. 2012) it was determined placing all dredged material within the current Point Chehalis Site boundaries may pose an adverse risk to navigation and O&M dredging costs. The unique grain size and other characteristics of dredged material derived from channel deepening make those sediments likely to accumulate within the placement sites at a faster rate than recently accrued material derived from maintenance dredging, based on historical trends of O&M material (Hayter et al. 2012). The Federal navigation channel passes through the site and mounding of material can result in loss of channel depth and width without proper site management. The site capacity analysis recommended a 1,000-foot north-northwestern shift in the placement site and placement of dredged materials over the entire placement site (Figure 15). This shift produces less sedimentation in the navigation channel and less accumulation above authorized channel depths over the course of dredged material placement (Hayter et al. 2012). As a result of the site capacity analysis, the Corps would place dredged material at the Point Chehalis placement site under Alternative 2 as per this recommended shift (as described in Appendix H). This placement site shift would not increase the size of the Point Chehalis Site and would be a temporary one time shift to accommodate the volumes of material to be placed during the construction year by taking advantage of deeper water and more dispersive hydrodynamics. The site would be shifted back after the construction year's activities of deepening are completed.

The upland Point Chehalis Revetment Extension mitigation site would be recharged when feasible with dredged material from a hopper dredge with hydraulic pump-ashore capability. The hopper would dredge sand from the navigation channel and transit to a mooring dolphin within Half Moon Bay and hydraulically pump dredged material via a floating or submerged pipeline into the mitigation site. Water discharged from the dredge slurry will be contained by dikes around the perimeter of the mitigation site. The sandy dredged material would quickly dewater and a bulldozer would grade the sand uniformly over the placement area. The slurry of water and sand would temporarily pond in the placement site as the dredged sediments settle out of suspension, and decant water would be conveyed via effluent pipe into Grays Harbor at the exposed rock revetment near Groin A. A water quality monitoring plan would be implemented in accordance with an approved Water Quality Certification issued by the Washington Department of Ecology. As with Alternative 1, material placed above MHHW in the Point Chehalis Revetment Extension mitigation site is expected to subsequently erode through natural processes, with portions of the material entering the intertidal zone and thus the littoral system.

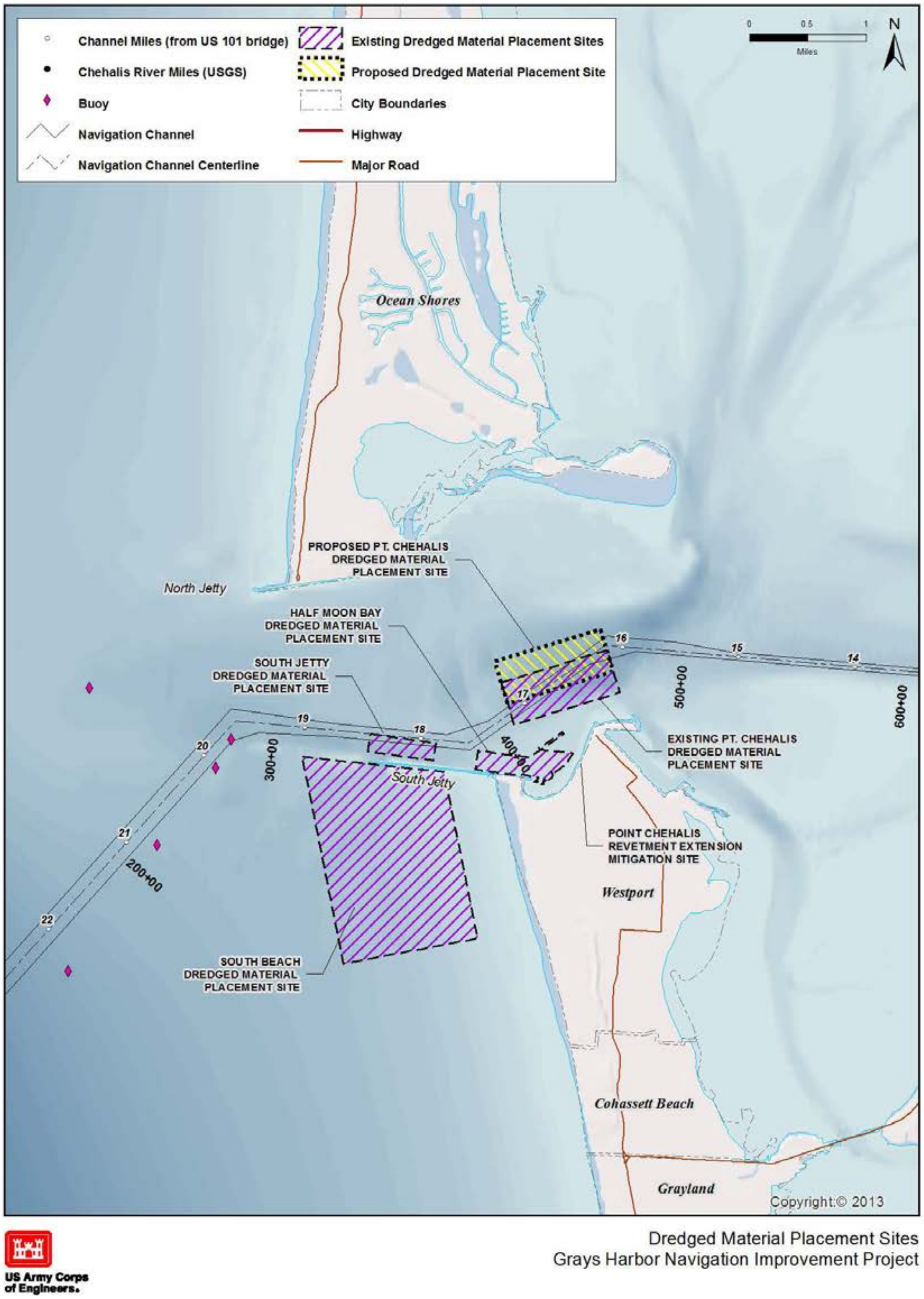

Figure 15: Point Chehalis Placement Site Shift for Alternative 2 and Alternative 3

The latest suitability determination, prepared under the DMMP (Appendix A of the SEIS), showed that a vast majority (more than 98%) of the sediments from the inner harbor reaches are suitable for open-water placement. Approximately 13,500 cubic yards of sediment that would be dredged during construction of Alternative 2 from the Cow Point 32a subunit are unsuitable for open-water disposal because of toxicity expressed in the sediment larval bioassay. This material would require appropriate upland disposal. Further explanation of channel sediment suitability is provided in Sections 3.7 and 4.7 of Appendix C to this document (SEIS), *Water Quality and Sediment Characterization*, as related to the affected environment and environmental consequences, respectively.

The approximately 13,500 cubic yards of material determined to be unsuitable for open water disposal underwent extensive testing, consisting of three rounds of chemical analysis and bioassays (Appendix A of the SEIS). In the first round of chemical testing, the material exceeded the DMMP screening level for benzyl alcohol, but in subsequent rounds this chemical was either below the screening level or undetected. Bioassay testing results were equivocal, with the same species of amphipod exhibiting toxicity in one test but not another; and with the larval bioassay results ranging from no toxicity to significant toxicity depending on the testing round and termination protocol used. The uncertainty surrounding bioassay results for this material and adjacent material was compounded by elevated levels of ammonia. The ammonia results were unequivocal for the final round of amphipod testing and the amphipod results were rejected as a result. However, an analysis of the sediment larval data relative to ammonia did not provide unequivocal evidence that ammonia was responsible for the toxicity exhibited in the larval test. Therefore, the DMMP agencies made an environmentally conservative call and found the material in subunit CP32a unsuitable for open-water disposal. However, the material is not a Resource Conservation and Recovery Act regulated material (not a hazardous waste) and does not pose a human health risk. Risk to human health and higher-order ecological receptorsis assessed by exceedances of the DMMP bioaccumulation triggers (and bioaccumulation testing in the event that bioaccumulation triggers are exceeded). Benzyl alcohol is not a bioaccumulative chemical of concern and, therefore, does not have a bioaccumulation trigger. There were no bioaccumulation trigger exceedances for any of the chemicals of concern tested for this project.

The unsuitable material will be clamshell dredged. Implementation of best management practices – such as control of the speed of the dredging bucket during descent and ascent – and compliance with the water quality monitoring plan will ensure that turbidity is reduced to the maximum extent possible during dredging. Dredged material will be placed in a fully fenced haul barge where it will be dewatered through filtered scuppers to control turbidity in water returning to Grays Harbor. Contaminants are generally associated with the sediment itself and with suspended sediment particles in the water column. By minimizing the loss of suspended particles during dewatering, loss of any chemical contaminants associated with the sediment will also be minimized. The dredged material would be dewatered and taken by barge to be offloaded at nearby Port of Grays Harbor Terminal 3 (a distance of less than 4 miles) and trucked the short distance to the former Hoquiam city wastewater treatment lagoon for offload (less than half-a-mile), and dumped from the transport trucks directly into the offload site. The dewatered dredged material would be mechanically transferred from the barge to trucks using an excavator or front load excavator. The lagoon is a former wastewater treatment pond formerly utilized by the city of Hoquiam for treatment of municipal sewage. Approval for usage will require acquisition of real estate interests and any applicable State permits which will be obtained by the Port of Grays Harbor. The methodology for placing the material is expected to consist of dredging via clamshell dredge and barge with mechanical rehandling of material on land. During dredging the barge would be lined with geotextile fabric to prevent leakage. The barge would be transported to Port of Grays Harbor Terminal 3 and dewatered through a sump pump with a geofabric bag surrounding the discharge pipe to contain sediments. Land-based equipment would be used to transfer and transport the dewatered dredged material from the barge to the placement area along the southern edge of the former waste water treatment lagoon as depicted in Figure 15. The Corps expects the Port of Grays Harbor to acquire and thereafter own the parcel on which the former wastewater treatment lagoon is located. The Port is expected to further develop the property following placement of dredged material under Alternative 2, and thus will assume responsibility for any monitoring, maintenance, and adaptive management of that material following placement.

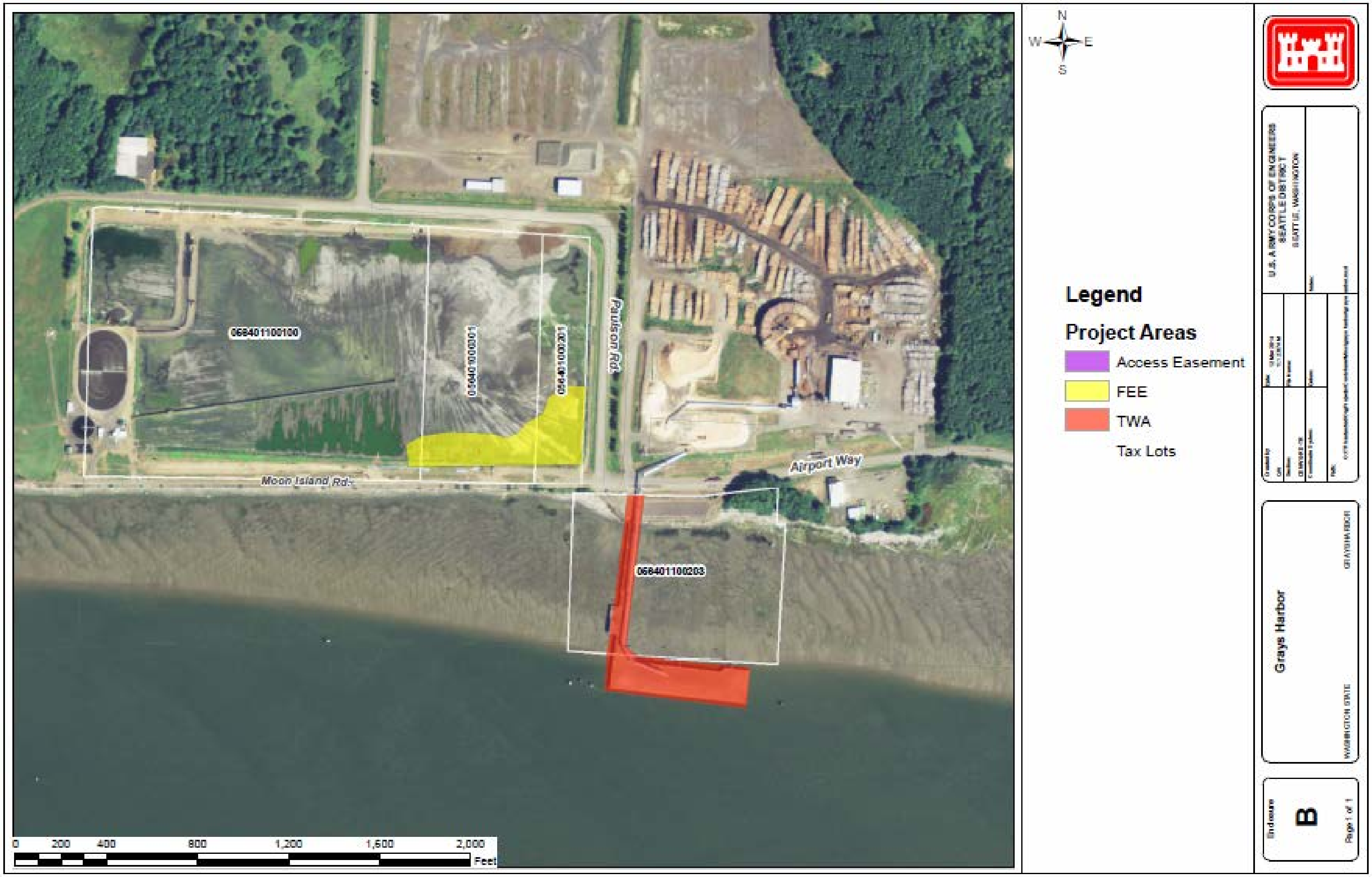

Figure 16: City of Hoquiam Wastewater Treatment Lagoon, Located Near Port of Grays Harbor Terminal 3, for Alternative 2 and Alternative 3

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The volume of 2,311,000 cubic yards is required to be dredged to reach -36 feet MLLW prior to any deepening. This volume is computed based on the August 2013 condition survey. Actual volumes in the deepening construction year would be determined based on bathymetric surveys of the channel just prior to deepening.

Annual maintenance dredging to -36 feet MLLW would be required to be performed in the same year as the deepening construction dredging. The estimated volume of material to be removed during dredging from the maintained depth of -36 feet MLLW to the deepened depth of -37 feet MLLW and the anticipated volume removed annually during maintenance dredging attributable to the deepening are shown in Table 18. The volumes listed include 2 feet of advance maintenance and 2 feet of allowable overdepth. Thus total volumes dredged for both maintenance to -36 feet and deepening from -36 feet to -37 feet MLLW in the construction year requires an estimated 3,120,000 cubic yards. However, the environmental impacts analysis for Alternative 2 documented in the attached SEIS is focused on the difference as compared with Alternative 1: the deepening volumes (above 2.09 mcy) and subsequent increased maintenance attributable to that deepening (50,000 cubic yards annually).

Initial deepening of the channel by 1 foot would require excavation (and placement) of an additional 811,000 cubic yards of sediment. Subsequent annual maintenance volumes for project operation are estimated to increase by approximately 50,000 cubic yards annually over the 50 year project span. This represents an increase in annual maintenance dredging of 2% to maintain the channel at -37 feet MLLW.

All volume estimates take into account the reduced amounts attributable to the minor channel re-alignment that has previously been evaluated and will have been undertaken prior to the execution of this proposed action. The estimated dredge volumes presented here and environmental evaluation of potential effects of channel deepening in this report are assessed in light of prior implementation of the minor channel alignment modification.

As noted in the table, the economic analysis, employed consistent with Corps project planning principles and policies, assumed deepening would start at -36 ft MLLW, and used the deepening increments below -36 ft MLLW for Alternative 2 and Alternative 3.

Table 19: Estimated Dredged Material Volumes (cubic yards) by Reach to Deepen Navigation Channel to -37 feet MLLW under Alternative 2

Navigation Channel Reach	Construction Increment Attributable to Channel Deepening from -36 ft MLLW to –37 feet MLLW	Total Dredged in Construction Year[c]	Annual Increase in Maintenance Dredging Attributable to Deepening to -37 feet MLLW[d]
Inner Harbor Reaches			
Cow Point[b]	171,000	980,000	10,000
Hoquiam	172,000	671,000	11,000
North Channel	126,000	371,000	8,000
Inner Crossover	129,000	596,000	8,000
Outer Harbor Reaches			
Outer Crossover	121,000	330,000	7,000
South	92,000	172,000	6,000
Total	**811,000**	**3,120,000**	**50,000**

[a] Assumes deepening would begin from –36 feet MLLW and includes advanced maintenance and overdepth dredging volumes, as well as 15% contingency to account for potential variability in sedimentation rates from year to year. Initial channel deepening volumes obtained from the August 2013 condition survey by the Corps vessel *Shoalhunter*.

[b] Volumes include the Cow Point Turning Basin.

[c] Total volume represents neatline volume to -37 feet MLLW, including all O&M dredging above -36 feet MLLW.

[d] Increased annual maintenance attributable to the one foot deepening increment from -36 ft to -37 ft MLLW (Rosati 2004)

5.3 Alternative 3: Deepen Channel to -38 Feet MLLW

Alternative 3 would meet the planning objectives of this study by deepening the navigation channel an additional two feet, compared to baseline conditions (Alternative 1), to a depth of −38 feet MLLW. Following deepening, the channel would thereafter be maintained at the new design depth of -38 feet MLLW for a period of 50 years, through annual maintenance dredging in a manner identical to Alternative 1 with the exception of a minor increase in dredged material volumes. Under this alternative, project construction (i.e., initial dredging), including scheduled work periods, types of equipment, and methods for dredged material placement, would be implemented as described for construction dredging under Alternative 2. Construction dredging of Alternative 3 would occur over approximately six months for the inner harbor reaches (the same as Alternative 2), and would occur within the same seven month dredge window as under Alternatives 1 and 2. The duration of dredging for the outer harbor reaches would be approximately 1 month, the same as under Alternatives 1 and 2. Dredged materials would be deposited at the placement sites as identified in Alternative 2, using the same prioritization methodology. An additional clamshell dredge and barge would be needed under this alternative.

Approximately 22,400 cubic yards of sediment that would be dredged during construction of Alternative 3 from the Cow Point 32a subunit are unsuitable for open-water disposal because of toxicity expressed in the sediment larval bioassay. This material would be handled and placed as described in Section 2.3 for Alternative 2 and shown above.

Initial deepening of the channel by 2 feet would require excavation (and placement) of an additional 1.752 million cubic yards of sediment beyond that volume required to reach a depth of -36 feet MLLW. Subsequent annual maintenance volumes are estimated to increase by 107,000 cubic yards. This represents an increase in annual maintenance dredging of 5% to maintain the channel at -38 feet MLLW.

The estimated volume of material to be dredged during project construction and the anticipated volume removed annually during maintenance dredging are shown in Table 20. As is the case with Alternative 2, annual maintenance dredging to -36 feet MLLW would be required to be performed in the same year as the deepening construction dredging. Maintenance dredging to reach -36 feet MLLW in the deepening reaches is estimated at 2,311,000 cubic yards. Thus total volumes dredged for both maintenance to -36 feet and deepening from -36 feet to -38 feet MLLW in the same year requires an estimated 4,061,000 cubic yards (Table 20). However, the environmental impacts analysis for Alternative 3 is focused on the differences as compared with Alternative 1: the deepening volumes (above 2.09 mcy) and subsequent increased maintenance attributable to that deepening (107,000 cubic yards annually). The volumes listed include 2 feet of advance maintenance and 2 feet of allowable overdepth.

As noted in the table, the economic analysis, employed consistent with Corps project planning principles and policies, assumed deepening would start at -36 ft MLLW, and used the deepening increments below -36 ft MLLW for Alternative 2 and Alternative 3.

Note that the environmental analysis documented in the SEIS for this study evaluated effects of deepening below the annual average volume of dredged material of 2.09 mcy, consistent with an analytical approach that compares the environmental effects of the preferred alternative against the effects of the NEPA no-action alternative. The dredging volumes for the NEPA no-action alternative thus differ from the LRR without-project alternative, and the dredging volumes for the increment attributable to the proposed action in the SEIS thus also differ from the construction increment attributable to channel deepening indicated in Table 20, below.

Table 20: Estimated Dredged Material Volumes (cubic yards) by Reach to Deepen Navigation Channel from -36 ft MLLW to -38 ft MLLW under Alternative 3

Navigation Channel Reach	Construction Increment to Deepen Channel to –38 feet MLLW	Total Dredged in Construction Year[c]	Annual Increase in Maintenance Dredging Attributable to Deepening to -38 feet MLLW[d]
Inner Harbor Reaches			
Cow Point[b]	348,000	1,158,000	21,000
Hoquiam	359,000	857,000	22,000
North Channel	274,000	519,000	17,000
Inner Crossover	264,000	731,000	16,000
Outer Harbor Reaches			
Outer Crossover	257,000	466,000	16,000
South	250,000	330,000	15,000
Total	**1,752,000**	**4,061,000**	**107,000**

[a] Assumes deepening would begin from –36 feet MLLW and includes advanced maintenance and overdepth dredging volumes. Initial channel deepening volumes obtained from the August 2013 condition survey by the Corps vessel *Shoalhunter*.

[c] Total volume represents neatline volume to -38 feet MLLW, including all O&M dredging above -36 feet MLLW.

[d] Increased annual maintenance attributable to the two foot deepening increment from -36 ft to -38 ft MLLW (Rosati 2004)

6 Future with Project Alternatives Evaluation, Comparison and Selection of Recommended Plan

6.1 Future with Project Vessel Movements

The increased volume in commodities moved through the Port during the 50-year period of analysis described above is expected to be enabled by an increase in the number of vessels over the same period. This increase in vessel traffic anticipated over time in any of the three alternatives would not be caused by the deepening action, because channel dimensions are not a present or expected limiting factor on cargo growth, and the vessel traffic increase is expected to occur independent of the deepening because of the growth in commodity volume.

In addition, the future with and without project vessel origin and destination are expected to be the same, and the overall size and type of vessels will remain relatively unchanged regardless of whether a deepening project is implemented. The without-project condition is defined as without further deepening – i.e. currently implemented and maintained project of -36 feet MLLW. The vessel fleet (size and type) was held reasonably constant for multiple reasons; based on information provided by the Port, commodity tonnage forecast, and the fact there is no need for changes to the existing fleet beyond the increase in vessel port call numbers projected to occur independently of implementation of either Alternative 2 or Alternative 3 to handle the commodities expected to transit Grays Harbor. In addition, the introduction of larger vessels, those beyond what are already calling, would reintroduce the inefficiencies the recommended project is intended to alleviate.[3] A movement to these larger vessels would require these vessels to light load and or tide ride to utilize the existing channel, thus reintroducing higher transportation cost.

While the estimated volume of commodities is expected to increase over time, the estimated volume of commodities is projected to be approximately the same in any given year of the 50-year period of analysis between Alternative 1, Alternative 2 and Alternative 3. Growth in cargo throughput volumes is thus independent of project implementation. This information is

[3] Currently, a mix of break bulk, dry bulk, roll-on/roll-off (Ro-Ro), barge, and tanker vessels call at the Port, the largest of which are Panamax vessels (50,001 – 80,000 dwt), which have a maximum length overall of 965 ft , 106 ft beam, and 39.5 ft draft in order to fit through the Panama Canal. Although Panamax vessels currently call at the Port, they cannot fully load and/or must wait for high tides to transit due to insufficient channel depth. Deepening the navigational channel from -36' to -38' MLLW will allow for more efficient operation of Panamax vessels. However, because the industry does not operate a discrete size category of vessels within the band between a 36-foot draft and a 39.5-foot draft, deepening is not anticipated to allow for larger bulk or tanker vessel classes to call at the Port as doing so would reintroduce the inefficiencies (light loading and tide riding) that the deepening is intended to alleviate. Ro-Ro vessels, with a draft of no more than 32 feet, are not generally depth limited at the Port, dependent on underkeel clearance requirements. Larger bulk classes such as Capesize (typically 175,000 dwt, but up to 400,000 dwt), with a draft of 60 feet and deeper, or larger tankers, such as Aframax (80,000 – 119,000 dwt), with a typical 60-foot draft, would not be expected to call at the Port at a -38-foot MLLW depth. Larger containerized vessels, such as Post-Panamax vessels, requiring 45 feet of depth, are not expected to call at the Port due to lack of container terminals, cranes, and other specialized facilities necessary to accommodate said cargo.

discerned from the observation that the vessel fleet (size and type) would remain relatively the same due to the aforementioned reintroduction of inefficiencies that would prevail with the change to a larger vessel. The additional two feet of depth, after reviews of the existing world fleet, does not indicate a need or reason to change to a different vessel type. The economic analysis shows that the number of vessels decreases between Alternative 1 and Alternative 2, and between Alternative 2 and Alternative 3 in any given year in the 50-year period of analysis because the additional depth provided under either Alternative 2 or Alternative 3 would allow each vessel to carry more goods on average. Fewer vessels moving the same amount of goods is a transportation cost savings, which is counted as an economic benefit for this analysis. In addition, vessels that are expected to traverse the channel would gain efficiencies by experiencing a reduction in delays associated with tide. The reduction in delays is attributable to an increase in the available time to utilize the tide fluctuations due to additional depth under Alternative 2 or Alternative 3, and is also attributable to relief in traffic congestion due to a reduction in the number of vessels (vessel traffic) traversing the channel. **Error! Not a valid bookmark self-reference.** below summarize estimated vessel traffic when comparing the without project condition and the with-project conditions under the two action alternatives. As explained in Section 4.2, because an economically conservative moderate growth projection is used here for economic analysis purposes, while an environmentally conservative optimistic growth projection is used in the SEIS for environmental effects analysis purposes, the projection of future with-project condition vessel movements under Alternative 3 will be different in the SEIS.

Table 21: Total Vessel Calls

Estimated Vessel Calls (Entire Forecasted Commodity Tonnage)					
2017 Without Project		**2017 With Project -37MLLW**		**2017 With Project -38MLLW**	
VesselClass	**Calls**	**VesselClass**	**Calls**	**VesselClass**	**Calls**
ATB 30k	122	ATB 30k	122	ATB 30k	122
Bulker 30k	4	Bulker 30k	4	Bulker 30k	4
Bulker 40k	5	Bulker 40k	5	Bulker 40k	5
Bulker 50k	15	Bulker 50k	10	Bulker 50k	9
Bulker 60k	22	Bulker 60k	22	Bulker 60k	22
Bulker 80k	3	Bulker 80k	3	Bulker 80k	3
Ro-Ro 10k	22	Ro-Ro 10k	22	Ro-Ro 10k	22
Ro-Ro 20k	8	Ro-Ro 20k	8	Ro-Ro 20k	8
Tanker-Medium	130	Tanker-Medium	126	Tanker-Medium	123
Tanker-Small	7	Tanker-Small	7	Tanker-Small	7
Total	**338**		**329**		**325**
2027 Without Project		**2027 With Project- 37MLLW**		**2027 With Project -38MLLW**	
VesselClass	**Calls**	**VesselClass**	**Calls**	**VesselClass**	**Calls**
ATB 30k	134	ATB 30k	134	ATB 30k	134
Bulker 30k	6	Bulker 30k	6	Bulker 30k	6
Bulker 40k	7	Bulker 40k	7	Bulker 40k	6
Bulker 50k	9	Bulker 50k	8	Bulker 50k	5
Bulker 60k	25	Bulker 60k	25	Bulker 60k	24
Bulker 80k	5	Bulker 80k	5	Bulker 80k	5
Ro-Ro 10k	19	Ro-Ro 10k	19	Ro-Ro 10k	19
Ro-Ro 20k	17	Ro-Ro 20k	17	Ro-Ro 20k	17
Tanker-Medium	132	Tanker-Medium	128	Tanker-Medium	126
Tanker-Small	13	Tanker-Small	13	Tanker-Small	13
Total	**367**		**362**		**355**
2037 Without Project		**2037 With Project -37MLLW**		**2037 With Project -38MLLW**	
VesselClass	**Calls**	**VesselClass**	**Calls**	**VesselClass**	**Calls**
ATB 30k	149	ATB 30k	149	ATB 30k	149
Bulker 30k	6	Bulker 30k	6	Bulker 30k	6
Bulker 40k	9	Bulker 40k	9	Bulker 40k	9
Bulker 50k	6	Bulker 50k	4	Bulker 50k	4
Bulker 60k	25	Bulker 60k	25	Bulker 60k	25
Bulker 80k	8	Bulker 80k	8	Bulker 80k	6
Ro-Ro 10k	20	Ro-Ro 10k	20	Ro-Ro 10k	20
Ro-Ro 20k	28	Ro-Ro 20k	28	Ro-Ro 20k	28
Tanker-Medium	134	Tanker-Medium	130	Tanker-Medium	127
Tanker-Small	15	Tanker-Small	15	Tanker-Small	15
Total	**400**		**394**		**389**

6.2 Economic Analysis of Alternatives

The base economic benefit of a navigation project is reduction in the value of resources required to transport commodities. National Economic Development (NED) deep-draft navigation benefits generally fall into three major groups but with respect to this study the most prominent is the reduction in the cost of transport. The benefits attributed to transportation cost savings are due to the elimination or reduction in transit times, the use of larger and more efficient vessel loadings, the use of alternative mode (land versus water), and/or the anticipated net reductions in vessel accident rates between the without and with project conditions.

The economic feasibility and justification of the recommended plan for this study were determined by comparing future without project conditions under the No Action alternative to the future with-project conditions under the two action alternatives. This involved comparing average annual costs and average annual benefits during the 50-year period of analysis. The plan that maximizes net benefits (average annual benefits less average annual cost) is the plan that maximizes net benefits for NED. This plan is the federal recommended plan. The plan that maximizes net benefits and meets the study objective to reduce navigation transportation costs for the existing and projected future traffic of deep-draft vessels, and improve efficiency and reliability of navigation to and from Grays Harbor over the next 50 years as feasible and economically justified, based on this limited economic analysis, is Alternative 3: Deepen Channel to -38 MLLW. The following sections summarize the analysis. Details of the modeling and results are in Appendix A (Economic Analysis).

Transportation cost savings were calculated using the HarborSym model, a planning-level simulation designed to assist in the economic analysis of coastal harbors using data such as port layout, vessel calls and transit rules to calculate vessel interactions within the harbor (see Appendix A for detailed description of model setup and inputs.)

6.3 NED Benefits

NED benefits are increases in the economic value of goods and services that result directly from a project. NED benefits are increases in national wealth, regardless of where in the U.S. they occur (IWR, 1991). With respect to navigation, NED benefits are the reduced transportation costs. Benefits attributed to the Grays Harbor NIP are mainly transportation cost savings due to the elimination of vessel calls or reduction in transit times as a result of more efficient vessel loadings.

Benefits are the difference between the without project transportation cost (Alternative 1) and the estimated transportation cost with deepening (Alternative 2 and Alternative 3.) All costs were adjusted to the base year of the project (2017) and were then converted to Average Annual Equivalent (AAEQ) values using the Fiscal Year (FY) 2014 federal discount rate of 3.5 percent, assuming a 50-year study period. All costs are at August 2013 price levels. The benefits calculation does not project, and does not rely upon, an expectation of growth in numbers of vessel calls or an increase in cargo throughput attributable directly and exclusively to implementation of the recommended alternative. In the absence of modeling evidence clearly demonstrating that implementation of the recommended plan will directly or indirectly induce economic growth in the form of an increase in number of vessel calls and/or increase in cargo tonnage passing through the Port of Grays Harbor, this benefits calculation is founded on the conservative premise that the project will not generate those economic growth gains. The SEIS, found at Appendix C, adopts a premise in light of the uncertainty over the prospect of induced economic gains that is conservative from the perspective of environmental impact evaluation: the SEIS assumes a reasonable projection of economic growth in the form of increase in number of vessel calls and increase in cargo tonnage, and assesses the corresponding anticipated environmental impacts.

6.4 NED Costs

NED costs are defined as opportunity cost and as such may or may not come in many different forms. There are economic costs (explicit) and financial costs (implicit) that may overlap. Financial costs are synonymous with accounting costs or actual expenses. Economic costs can be an exercise in theory on how resources such as land or other national resources could better be used or the value of that which is foregone (opportunity cost).

The relevant costs for project evaluation have been determined by policy to be NED costs. The Planning Guidance Notebook (ER 1105-2-100) states that NED costs are used for the economic analysis of alternative projects and reflect the opportunity cost of direct or indirect resources consumed by project implementation.

The financial costs were provided by the Seattle District Cost Engineering Department and were developed through the Micro-Computer Aided Cost Estimating System (MCACES) 2nd generation (see Appendix E, Cost Estimate).

The cost of current annual maintenance dredging at Grays Harbor is approximately $8-10 million for -36 feet MLLW. This dollar amount is expected to change under the two deepening alternatives because the volume of material to be dredged would increase incrementally. To derive the benefits, the economic analysis compared the change in operational cost savings from Alternative 1 (-36 feet MLLW) to Alternative 2 (-37 feet MLLW) and Alternative 3 (-38 feet MLLW). The O&M for the economic analysis for Alternative 2 and Alternative 3 is expected to see an incremental change. The incremental cost increase from the current operations (without project) to the -with project (-37, and -38 MLLW) were added to the total project cost. The incremental increase of Alternative 2 and Alternative 3 are found in Table 22 below.

Table 22: Grays Harbor Incremental Operation and Maintenance Volumes and Costs Attributable to Alternative 2 and Alternative 3

Grays Harbor Incremental Operation and Maintenance		
Alternative	**Volume (Cubic Yards)**	**Total Cost**
Alternative 2 (-37 MLLW)	50,000	$ 272,000
Alternative 3 (-38 MLLW)	107,000	$ 590,000

Additional costs were added to account for the interest during construction (IDC) that would accrue. That is the opportunity cost of not using the funds tied up in the project for other purposes. The FY14 federal interest rate of 3.5% along with a construction period of approximately 8 months was used to derive the IDC. The NED costs for Alternative 2 and Alternative 3 are found in the tables below.

Table 23: NED Costs Alternative 2 (Deepen Channel to -37 MLLW)

NED COSTS -37 FT MLLW	
Estimated Total project Costs	$11,125,000
Interest During Construction	$112,000
Total	$11,237,000

Table 24: NED Costs Alternative 3 (Deepen Channel to -38 MLLW)

NED COSTS -38 FT MLLW	
Estimated Total project Costs	$18,384,000
Interest During Construction	$186,000
Total	$18,570,000

6.5 Annual Cost Savings

Table 25 displays expected cost savings associated with operation each year from 2017 to 2067 for Alternative 2 and Alternative 3.

Table 25: Annual Transportation Cost and Transportation Cost Savings (Benefit)

Annual Cost and Benefit Stream					
	Alt 1 (No Action)	Alt 2 (-37MLLW)		Alt 3 (-38MLLW)	
Year	Transit Cost	Transit Cost	Transit Benefit	Transit Cost	Transit Benefit
2017	**$ 134,794,705**	**$ 131,750,827**	**$ 3,043,878**	**$ 126,361,068**	**$ 8,433,637**
2018	$ 136,005,703	$ 132,731,187	$ 3,274,516	$ 127,708,759	$ 8,296,944
2019	$ 137,216,701	$ 133,711,547	$ 3,505,154	$ 129,056,450	$ 8,160,251
2020	$ 138,427,699	$ 134,691,907	$ 3,735,792	$ 130,404,140	$ 8,023,558
2021	$ 139,638,697	$ 135,672,267	$ 3,966,430	$ 131,751,831	$ 7,886,865
2022	$ 140,849,695	$ 136,652,627	$ 4,197,068	$ 133,099,522	$ 7,750,173
2023	$ 142,060,692	$ 137,632,986	$ 4,427,706	$ 134,447,213	$ 7,613,480
2024	$ 143,271,690	$ 138,613,346	$ 4,658,344	$ 135,794,904	$ 7,476,787
2025	$ 144,482,688	$ 139,593,706	$ 4,888,982	$ 137,142,594	$ 7,340,094
2026	$ 145,693,686	$ 140,574,066	$ 5,119,620	$ 138,490,285	$ 7,203,401
2027	**$ 146,904,684**	**$ 141,554,426**	**$ 5,350,258**	**$ 139,837,976**	**$ 7,066,708**
2028	$ 148,446,378	$ 143,343,692	$ 5,102,686	$ 141,420,615	$ 7,025,763
2029	$ 149,988,072	$ 145,132,957	$ 4,855,115	$ 143,003,254	$ 6,984,818
2030	$ 151,529,766	$ 146,922,223	$ 4,607,543	$ 144,585,894	$ 6,943,872
2031	$ 153,071,460	$ 148,711,489	$ 4,359,971	$ 146,168,533	$ 6,902,927
2032	$ 154,613,154	$ 150,500,755	$ 4,112,400	$ 147,751,172	$ 6,861,982
2033	$ 156,154,848	$ 152,290,020	$ 3,864,828	$ 149,333,811	$ 6,821,037
2034	$ 157,696,542	$ 154,079,286	$ 3,617,256	$ 150,916,450	$ 6,780,092
2035	$ 159,238,236	$ 155,868,552	$ 3,369,684	$ 152,499,090	$ 6,739,146
2036	$ 160,779,930	$ 157,657,817	$ 3,122,113	$ 154,081,729	$ 6,698,201
2037-2057	**$ 162,321,624**	**$ 159,447,083**	**$ 2,874,541**	**$ 155,664,368**	**$ 6,657,256**
Average Annual Benefits			**$ 3,661,000**		**$ 7,142,000**

These cost savings were annualized and taken as a benefit for implementing a project (see Table 26.)

Table 26: NED Analysis for Alternative 2 and Alternative 3

	Alternative 2 (Deepen Channel to -37 feet MLLW)	Alternative 3 (Deepen Channel to -38 feet MLLW)
Average Annual Benefits	$3,661.000	$7,142,000
Average Annual Cost	$751,000	$1,382,000
Net Benefits	$2,910,000	$5,760,000
Benefit to Cost Ratio	4.9	5.2

6.6 Risk and Uncertainty

The economic analysis conducted for this study included a risk-informed decision making process, which involved identifying assumptions, predicted variables, estimated values, and parameter values critical to the report recommendation and the value of each critical factor where the recommendations would change or feasibility would be questioned. The economic analysis used HarborSym, a planning tool developed to analyze deep draft navigation projects by evaluating the impact of various harbor improvements. The specific analyses address assumptions as to traffic projections, rates, vessel operating costs, vessel fleet composition or vessel fleet characteristics. See Appendix A, Economic Appendix, for a detailed discussion of assumptions and model limitations identified for this study.

6.6.1 Key Assumptions

The economic analysis included the following assumptions to facilitate the decision making process:

- The Port, based on infrastructure improvement projects totaling approximately $200 million dollars over the past decade, is expected to be able to accommodate the tonnage forecasted over the 50 year period of analysis[4].
- The vessel types (Tanker, Bulker, ATB, and Ro-Ro) do a reasonable job of capturing the size and type of vessel utilizing the Port of Grays Harbor.
- Vessel sizes were held reasonably constant during the economic analysis for ease of modeling[5]. This is not expected to change the outcome of the recommended alternative due to the fact that, generally, as vessel sizes increase, and with that an increase in the volume of commodities carried, so too do the economies of scale.
- Vessels of similar type and cargo are expected to have similar dock, undock, load, and unload rates.
- Vessels operating in the system do not have mechanical or human failure.
- The vessel route group (East Asia, Asia, and North America) captures most of the traffic utilizing the Port of Grays Harbor.
- Channel dimensions are not a present or expected limiting factor on projected cargo growth.
- The future with and future without project vessel origin and destination are expected to be the same6 as the base year 2017.
- The petroleum projected to be moved in the base year falls into the North America Route Group.
- Commodities would remain relatively the same throughout the 50-year period of analysis.
- Demand for commodities is expected to grow slightly over the 50-year period of analysis.
- Commodity forecast were held constant after 2037 due to the expectation that predictions become less accurate as time elapses.
- There is not expected to be a shift in destination, mode, or any induced movement of new cargo during the 50-year period of analysis.

[4] In 1986, prior to the spotted owl being an ESA listed species, the port moved approximately 4.5 to 4.6 million tons. This represents almost half of what is projected 20 years from now and was moved prior to millions of dollars of infrastructure improvements.
[5] Based on Vessel Trends that can be found in the Supplemental Environmental Impact Statement the Port has seen an increase in the overall size of vessels being utilized in the channel.
[6] Based on lease agreements and continued world demand for agricultural products the current customers of the Port of Grays Harbor are expected to continue business with the Port via its current resident companies.

- The tonnage transported through Grays Harbor is expected to be similar for future years under either with- or without-project conditions.
- Crude by Rail (CBR) enters the commodity mix around 2015, independent of project implementation, and the demand for fossil fuels continues to grow.
- CBR is expected to transit via the Port of Grays Harbor –with or without the project.
- The interest rate of 3.5% used to do the economic analysis would remain the same over the 50-year period of analysis.
- The under-keel clearance is 4.5 feet for all vessels utilizing the harbor and is based on expert elicitation.
- The benefits from the project are assumed to not have an economic multiplier effect.
- Modeling in 10 year increments, as opposed to annually, over the 50-year period of analysis and interpolating does a good job of capturing the cost associated with the years in between the modeled years.

6.6.2 Model Limitations

HarborSym is a planning tool developed to analyze deep draft navigation projects by evaluating the impact of various harbor improvements. However, like all planning models, there are limitations. Some key model limitations are:

- HarborSym requires detailed user-provided data and assumptions and relies heavily on the quality of the data available to complete the analysis.
- Cost that are accumulated outside of the actual vessels entering or exiting the harbor such as fixed cost, tug assistance cost, pilot cost, terminal fees, and externalities are not captured by the model.
- Hinterland transportation costs are not included in the model.
- External factors such as weather, emergencies, laws, or policies are not captured in the model.

6.7 Multi-Port Analysis

In 1982, Assistant Secretary of the Army for Civil Works ASA(CW) William Gianelli asked the U.S. Army Corps of Engineers to develop procedures for analyzing deep draft ports, which included data and analysis of competing ports. The basic problem was defined to be the need for a methodology to identify the traffic which could swing from or to the port under study with modest shifts in relative costs (between ports). A multiport analysis approach was developed by the Corps of Engineers and used to evaluate potential benefits due to savings on the land leg and port cost differentials. Combined land leg, port and ocean leg costs were then obtained for the port under study and its competing ports. Finally, the conditions under which some part of the traffic would logically be diverted from one port to another were discerned.

The Economist's role in multiport analysis is to identify relevant competing port trade flows based on analysis of trade routes, commodities, and port facilities. Commodity movements to or from competitive inland hinterlands to or from the same world trade areas are candidates for detailed analysis. Where the commodities are not identical (such as wheat and corn), or the trade routes are distinct (such as exports to different world areas), the opportunities for commodity transfers, based on port deepening alone, are likely to be low as is the case for the Port of Grays Harbor.

Multiport analyses may or may not be needed depending on circumstances. Specifically the Port of Grays Harbor's most likely competing ports are Tacoma, Portland, Kalama, Longview, and Seattle. For Tacoma and Seattle the leading export/import is containerized cargo, whereas at Grays Harbor the leading import/export is break-bulk, liquid bulk, and vehicles. In addition, the Port of Grays Harbor is predominantly export-based, whereas the overwhelming majority of trade at the Port of Tacoma and the Port of Seattle are imports. The Ports of Longview, Kalama, and Portland are at a minimum an additional 66 miles inland from the Pacific Ocean and require, at a minimum, an extra 16 hours for a vessel transit. The additional time moving through the Columbia River channel requires that a Harbor Pilot, that is generally costly, guide the vessel during the longer voyage through the channel. This is not the case with respect to the Port of Grays Harbor.

It is also believed that the additional 2 feet of depth proposed for the Port of Grays Harbor is not sufficient enough of a depth to warrant a change in commodity routes from the aforementioned Ports to Grays Harbor. One reason this is believed to be the case is the competing Ports have a depth that already exceeds what is requested in the Port of Grays Harbor. That is to say that the existing shipping companies are not expected to gain any advantages or enough of a cost savings, due to depth, by shifting goods moved through the competing Ports to the Port of Grays Harbor because they already have depths that exceed -38 MLLW.

In addition, and probably the most convincing argument for not needing a multiport analysis, Grays Harbor's hinterland and commodities are not identical to any of the aforementioned Ports. That is to say that Kalama, Longview, and Portland generally service agriculture grown within the Columbia River Valley, whereas the Port of Grays Harbor services agricultural products from the Midwest (Iowa, Minnesota, Missouri and Nebraska). In order for the Port of Grays Harbor to take advantage of goods produced in the Columbia River Valley they would need to be loaded on trains that would move past perfectly acceptable ports such as Kalama, Longview, and Portland. This is attributed to the setup of the existing infrastructure and rail corridor in the vicinity of the Columbia River Valley. For this transition to occur the cost per ton to move bulk items would have to be significantly cheaper at the Port of Grays Harbor than at said ports. This is highly unlikely due to the fact that Kalama, Longview, and Portland have channel depths that exceed the Port of Grays Harbor and are capable of being more efficient with respect to large bulkers.

Also of concern is the potential for other Ports to obtain business from the Port of Grays Harbor. This was analyzed and determined unfounded due to the fact that Grays Harbor is the basic business model of the Port of Grays Harbor is one of partnership. AGP, one of the major movers of agricultural products, owns the terminal where most of the agricultural tonnage is exported. This seven-state cooperative has invested millions of dollars in capital into the Port of

Grays Harbor. It is unlikely that AGP would walk away from the partnership with the Port of Grays Harbor when so much capital is at stake. The business partnership model is also adhered to at the other Ports mentioned and this same argument could be applied to them from the other perspective of business being lost from them to the Port of Grays Harbor.

These circumstances surrounding the Port of Grays Harbor lead us to believe that commodity transfers or change of mode between competing ports is not expected to happen. Thus any movement of goods and services from competing ports is expected to be minimal at best and as such a multiport analysis is assumed unwarranted for this project.

6.8 Sensitivity Analysis

A sensitivity analysis was conducted for this study to help ensure that a risk-informed decision was made by determining how changing an independent variable, such as growth rates, could impact a particular dependent variable (vessel operating cost) under a given set of assumptions. For this exercise, no growth after the base year of 2017 was modeled, followed by changing the FY14 discount rate to 7% on the existing analysis to see what, if any, changes in recommended plan selection might occur. In addition, the scenario in which the CBR commodity does not use Grays Harbor and was not replaced by any other commodity was modeled to ensure the project would be economically justified regardless of predicted commodity arrivals/flows. Modeling of the aforementioned analyses showed the recommended plan of Alternative 3 did not change. That is to say, after adjusting for the discount rate, elimination of CBR, and elimination of growth in cargo volumes trans-shipped, the overall selection and recommendation of the initial analysis does not change. All sensitivity analysis was modeled separately from one another. Details of this sensitivity analysis are provided in Appendix A (Economic Analysis).

6.9 Environmental Consequences and Impact Determination

The SEIS (Appendix C of this LRR) provides a detailed description of the potential environmental consequences of each of the three alternatives evaluated during this study. Table 27 below summarizes the environmental consequences and impact determinations for the alternatives.

Although Alternative 3 would have a greater effect on the natural environment compared to Alternatives 1 and 2 due to a higher volume of material to be dredged and placed during the initial deepening, Alternative 3 is identified as the preferred alternative. Alternative 3 would best meet the project purpose and need and the planning study objective to reduce navigation transportation costs, and improve efficiency and reliability of navigation to and from Grays Harbor over the next 50 years as feasible and economically justified. Additionally, although Alternative 3 would have a greater effect on the environment, the environmental consequences analysis conducted for this study (and documented in the attached SEIS) determined that these effects would be minor.

Table 27: Environmental Consequences and Significance Determinations for Alternatives

Resource	Alternative 1 (No Action): Continue Channel Maintenance of -36 Feet MLLW	Alternative 2 (Deepen Channel to −37 Feet MLLW)	Alternative 3 (Deepen Channel to −38 Feet MLLW)
Marine Transportation	Navigation channel would be maintained in its existing condition; tidal delays for vessels exceeding 36 feet of draft and light loading of such vessels would continue due to channel depth. No change in marine transportation conditions; vessel operation constraints would continue.	Under keel vessel clearance would increase and thus lengthen tidal windows for loaded vessels to utilize the navigation channel. Additional 1 foot of depth would improve window of availability for vessel transits to a greater proportion of the tidal cycle compared to Alternative 1. A beneficial effect on marine transportation; vessel operations would be improved, allowing fuller loads per vessel and reducing ocean transportation costs.	Underkeel vessel clearance would further increase and thus further lengthen tidal windows for loaded vessels to utilize navigation channel. Additional 2 feet of depth would improve the window of availability for vessel transits to a greater proportion of the tidal cycle than deepening by 1 foot under Alternative 2. Beneficial effect on marine transportation anticipated, with a channel depth that best meets project's purpose and need; vessel operations would be improved, allowing fuller loads per vessel and reducing ocean transportation costs.
Geomorphology	Geomorphic attributes of navigation channel and estuary would be maintained in existing condition. Sediment transport dynamics, including the dynamics of the flood and ebb currents, and patterns of shoaling and erosion, would be expected to continue as currently occur. Placement of approximately 2 million cubic yards of dredged material at existing placement sites would continue.	Navigation channel depth would increase by 2.5%, with limited influence on the estuary's larger morphological processes. Slight increase in salinity concentration in deeper channel, but with negligible effect on the pressure gradients controlling saltwater intrusion. One-time placement of an additional 1,031,000 cubic yards of material, and the additional 50,000 cubic yards of annual maintenance is not expected to alter sediment transport dynamics. Potential for alterations in salt wedge dynamics, ship-wake erosion, erosion of navigation channel side slopes, Whitcomb Flats morphology, and sediment transport dynamics are expected to be minor.	Navigation channel depth would increase by 5%, with limited influence on the estuary's larger morphological processes. Slight increase in salinity concentration in deeper channel, but with negligible effect on the pressure gradients controlling saltwater intrusion. One-time placement of an additional 1,972,000 cubic yards of material, and the additional 107,000 cubic yards of maintenance dredging are not expected to alter sediment transport dynamics. Potential for alterations in salt wedge dynamics, ship-wake erosion, erosion of navigation channel side slopes, Whitcomb Flats morphology, and sediment transport dynamics are expected to be minor.
Aquatic and Terrestrial Vegetation	No direct impacts on eelgrass beds would occur. Eelgrass is not found in the navigation channel or at the placement sites because of low light levels/water depth, shifting substrate, and high tidal current. Short-term increases in turbidity during dredging and material placement could result in settlement of suspended sediments on eelgrass near the navigation channel, but effect expected to be rare and of short duration, with waves and tidal action quickly washing sediment from eelgrass fronds within 1 to 2 days.	The potential for alterations to eelgrass, macroalgae, saltmarsh, dunegrass, or sweet grass by deepening the channel 1 foot is expected to be negligible for the same reasons as noted for Alternative 1.	The potential for alterations to eelgrass, macroalgae, saltmarsh, dunegrass, or sweet grass by deepening the channel 2 feet is expected to be negligible for the same reasons as noted for Alternative 1.
Invertebrates, Fish, and Wildlife	Entrainment of aquatic invertebrates such as crabs, and a variety of epibenthic-associated fish such as flatfish, lingcod, and forage fish would occur at rates commensurate with the volume of material dredged via clamshell and hydraulic dredge to maintain the channel at -36 MLLW. Impacts are limited due to limited habitat in navigation channel (lingcod); high numbers of flatfish and forage fish in Grays Harbor, large spatial extent of foraging habitat (sturgeon), and per Dredge Impact Model (DIM) results for entrainment of Dungeness crab. Temporary displacement of seabirds, waterfowl and marine mammals may occur, but effect would be limited due to slow movement of dredges and confined footprint of noise and disturbance. Abundance of salmon, forage fish, groundfish, and benthic invertebrates are not measurably affected by maintenance dredging.	Deepening the inner harbor reaches would require an additional 45 days relative to Alternative 1, but would occur within the same in-water work window and at discrete locations in the channel at any one time. Hydraulic dredging to deepen the outer harbor reaches to -37 feet MLLW would entrain an additional estimated 77 to 2,156 flatfish, 77 to 154 lingcod, and 77 to 1,386 forage fish over Alternative 1 conditions if both south and outer crossover reaches are hopper dredged. Subsequent maintenance dredging would represent an approximate entrainment increase of 2.5% over Alternative 1. DIM results indicate that predicted Dungeness crab losses as a result of Alternative 2 are minimal and show little impact to harvestable size crabs (age 2+). The effects of Alternative 2 on invertebrates, fish, and wildlife are thus anticipated to be minor, and similar in nature and magnitude to those identified for Alternative 1.	One additional clamshell dredge, tug, and bottom dump barge would be employed during dredging of the inner harbor reaches compared to Alternatives 1 and 2. Deepening the inner harbor reaches would require an additional 45 days relative to Alternative 1, but would occur within the same in-water work window and at discrete locations in the channel at any one time. Hydraulic dredging to deepen the outer harbor reaches (both South Reach and potentially Outer Crossover Reach) to −38 feet MLLW would entrain an additional estimated 371 to 10,388 flatfish, 371 to 742 lingcod, and 371 to 6,678 forage fish, and subsequent maintenance dredging would represent an increase of 5% over Alternative 1 conditions. DIM results indicate that predicted Dungeness crab losses as a result of Alternative 3 are minimal and show little impact to harvestable size crabs (age 2+). The effects of Alternative 3 on invertebrates, fish, and wildlife are thus anticipated to be minor and similar in nature and magnitude to those

Resource	Alternative 1 (No Action): Continue Channel Maintenance of -36 Feet MLLW	Alternative 2 (Deepen Channel to −37 Feet MLLW)	Alternative 3 (Deepen Channel to −38 Feet MLLW)
			identified for Alternative 1.
Threatened and Endangered Species	Alternative 1 would not adversely affect threatened or endangered species. National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS) concurred in 2011 that continuation of the maintenance dredging from 2012 through 2026 would not result in likely adverse effects on any listed threatened or endangered species or designated critical habitat.	Dredging would require an additional 45 days for the inner harbor reaches, compared to Alternative 1, but the effect mechanisms of Alternative 1 would largely be the same. Alternative 2 would employ the same schedule, and would be conducted with the same number of dredging vessels and work hours per day as under Alternative 1, with the following exceptions: dredged material for upland mitigation site replenishment would be pumped ashore via submerged/floating hydraulic pipeline moored in Half Moon Bay, a long-reach excavator would be used to remove some material from the Cow Point Reach, material determined to be unsuitable for unconfined aquatic disposal would be transferred and disposed upland, and dredged material would be placed in a shifted Point Chehalis aquatic site during construction of the deepened channel. Placement sites would include South Jetty, Half Moon Bay, South Beach and the Point Chehalis Revetment Extension mitigation site as in Alternative 1, and would add the shifted Point Chehalis site and the upland placement of unsuitable material. Listed species, including juveniles, are not likely to experience water quality or disturbance effects in the navigation channel or burial effects at the dredged material placement sites, because they are unlikely to use the affected habitats, and/or their vulnerable life-history stages are not likely to be present at these sites during the timing of dredging and material placement. The effects of Alternative 2 on threatened and endangered species are thus anticipated to be minor and similar in nature and magnitude to those identified for Alternative 1.	One additional clamshell dredge, tug, and bottom dump barge would be employed during dredging of the inner harbor reaches compared to Alternative 2. Deepening the inner harbor reaches would require an additional 45 days relative to Alternative 1, but would occur within the same in-water work window and at discrete locations in the channel at any one time. Both dredges do not typically work in the same portion of the channel at the same time. The duration and area of disturbance associated with dredging activities under Alternative 3 would not differ significantly from levels that occur under Alternatives 1 and 2. Listed species are not likely to experience water quality or disturbance effects in the navigation channel or burial effects at the dredged material placement sites for the same reasons as noted for Alternative 2. The effects of Alternative 3 on threatened and endangered species are thus anticipated to be minor and similar in nature and magnitude to those identified for Alternatives 1 and 2.
Historic and Cultural Resources	No historic or cultural resources are known to occur in the navigation channel or at the dredged material placement sites.	Negligible effects are expected because no historic or cultural resources are known to occur in the navigation channel or at the dredged material placement sites.	Negligible effects are expected because no historic or cultural resources are known to occur in the navigation channel or at the dredged material placement sites.
Water Quality and Sediment Characterization	Based on the results of the February 2012 determination, all of the sediment that would be maintenance dredged under Alternative 1 is suitable for open-water placement. Dredging and placement of dredge materials have only short-duration, localized impacts on water quality. The turbidity and low-DO plume associated with the dredging and placement of dredged materials typically dissipates quickly due to the strong tidal currents and wave exposure, particularly at the open-water placement sites.	All sediment that would be dredged under Alternative 2 is suitable for open-water placement, with the exception of 13,500 cubic yards of material from the Cow Point 32a subunit. This material would be dredged and then removed to an appropriate upland placement site. Prior to subsequent maintenance dredging cycles, the Corps would contact the DMMP agencies to determine whether additional sediment testing in Cow Point Reach DMMU subunit 32a is required. The duration of dredging activities under Alternative 2 would be extended by 45 days compared to Alternative 1. Best management practices (BMPs) would ensure that water quality impacts remain localized and overall impacts remain negligible. The Corps will seek a CWA Section 401 water quality certification from Ecology and would abide by any requirements included therein for the protection of water quality, associated with the discharge of dredged material into waters of the United States. Minor effects are, therefore, expected.	All sediment that would be dredged under Alternative 3 is suitable for open-water placement, with the exception of 22,400 cubic yards of material from the Cow Point 32a subunit. This material would be dredged and then removed to an appropriate upland placement site (former Hoquiam waste water treatment lagoon). Prior to subsequent maintenance dredging cycles, the Corps would contact the DMMP agencies to determine whether additional sediment testing in Cow Point Reach DMMU subunit 32a is required. The duration of dredging activities under Alternative 3 would be extended by 45 days compared to Alternative 1. BMPs would ensure that water quality impacts remain localized and overall impacts remain negligible. The Corps will seek a CWA Section 401 water quality certification from Ecology and would abide by any requirements included therein for the protection of water quality, associated with the discharge of dredged material into waters of the United States. Minor effects are, therefore, expected.

Resource	Alternative 1 (No Action): Continue Channel Maintenance of -36 Feet MLLW	Alternative 2 (Deepen Channel to −37 Feet MLLW)	Alternative 3 (Deepen Channel to −38 Feet MLLW)
Air Quality, Noise, and Artificial Lighting	Alternative 1 constitutes a routine facility repair activity generating an increase in emissions that is clearly *de minimis* under 40 CFR 93.153(c)(1)(ix), and represents no changes in emission or air quality effects from the baseline conditions. The volume of emissions and related air quality and lighting effects that occur during maintenance dredging would continue.	Emissions of nitrogen oxides associated with deepening of the navigation channel under Alternative 2 (76 tons) in the construction year are below the General Conformity thresholds for non-attainment or maintenance areas (Grays Harbor is neither a non-attainment area nor a maintenance area).Air quality impacts are considered minor because of their relatively short duration (i.e., 6 months of inner harbor activity and 1 month for the outer harbor) and the low potential for pollutant concentrations to reach sensitive receptor locations.	Deepening of the inner harbor reaches would use more dredging machinery than under Alternative 2, resulting in greater air pollutant emissions. Emissions of nitrogen oxides associated with deepening of the navigation channel under Alternative 3 (84 tons) in the construction year are below the General Conformity thresholds for non-attainment or maintenance areas (Grays Harbor is neither). Total emissions for Alternative 3 are greater than those of Alternatives 1 and 2, but still relatively minor. As is the case with Alternative 2 dredging activities associated with deepening the navigation channel under Alternative 3 would have a relatively short duration (i.e., 6 months for the inner harbor reaches and 1 month for the outer harbor reaches), and low potential for pollutant concentrations to reach sensitive receptor locations.
Land Use and Aesthetics	Maintenance dredging activities do not conflict with current uses in Grays Harbor (e.g., shipping, recreational boating, fishing) or involve any elements that conflict with local plans or development regulations. The Grays Harbor viewshed includes the annual occurrence of dredge equipment, visible to observers from the shore and from the water. The visual appearance of these features is compatible with the existing large ships and commercial and recreational vessel traffic throughout Grays Harbor and particularly within the navigation channel.	No new features or elements would be introduced that would potentially conflict with or affect current land uses, land use planning, or aesthetic resources. Minor effects are anticipated because the dredging process, work periods, equipment, and the material placement methods and locations are the same as occur under Alternative 1 conditions, with the exception of the Point Chehalis placement site, possible use of a long reach excavator, pump ashore for upland placement at the Point Chehalis upland site, and the upland disposal of unsuitable material.	Negligible effects are anticipated for the same reasons as noted for Alternative 2.
Recreation	Recreational boaters (as well as commercial and tribal fishing vessels) are required to avoid the immediate area of dredging and placement for safety. The U.S. Coast Guard issues a *Notice to Mariners* announcing the locations and duration of dredging. The extent of dredging and placement of material is small and highly localized at any one time and can be easily be avoided. Dredging and dredge material placement does not conflict with recreational use of parks or wildlife viewing areas; placement of dredged materials helps slow erosion and maintain recreational activities along the South Jetty and Half Moon Bay area.	The dredging process, work periods, equipment, and the material placement methods and locations are the same as occur under Alternative 1 conditions, with the exception of the Point Chehalis site shift, possible use of a long reach excavator, pump ashore for upland placement at the Point Chehalis upland site and the upland disposal of unsuitable material. Placement of dredged material from the channel deepening under Alternative 2 at the Half Moon Bay and South Jetty sites would moderate erosion and help maintain these areas for recreational uses, potentially resulting in a beneficial effect on recreational resources.	Minor effects anticipated for the same reasons as noted for Alternative 2.
Global Climate Change	Maintenance dredging emissions would continue to contribute to the total greenhouse gas (GHG) atmospheric burden, but the quantity of emissions is a tiny fraction of all anthropogenic sources of GHGs. However, because global climate change is recognized to be an evolving cumulative effect, this relatively small amount of GHG emitted from maintenance dredging activities is acknowledged to be a contributor (albeit minor) to cumulative global emissions of GHGs.	Approximately 821 metric tons CO_2e would be emitted over Alternative 1 conditions due to the additional 45 days of dredging of the inner harbor reaches. Emissions would fall below the NEPA guidance recommended threshold of 25,000 metric tons for conducting a quantitative effects assessment, and the effects are considered to be minor.	Approximately 1,375 metric tons CO_2e would be emitted over Alternative 1 conditions due to the additional clamshell dredge and tugboat and the additional 45 days of dredging needed to deepen the inner harbor reaches. Emissions would fall below the NEPA guidance recommended threshold of 25,000 metric tons for conducting a quantitative effects assessment, and the effects are considered to be minor.

Resource	Alternative 1 (No Action): Continue Channel Maintenance of -36 Feet MLLW	Alternative 2 (Deepen Channel to −37 Feet MLLW)	Alternative 3 (Deepen Channel to −38 Feet MLLW)
Local Economy/ Socioeconomics	The -36 feet MLLW depth of the navigation channel constrains the operations of the existing fleet of vessels utilizing the harbor for water-oriented business, resulting in delays to arrivals and departures as well as light loading.	The additional 1 foot of channel depth would improve the window of availability for vessel transits, which would provide increased socioeconomic support to the region. While entrainment of fish and crabs would occur during the deepening, such impacts are expected to be minor. Alternative 2 would have a beneficial effect on the local economy and socioeconomics of the area because vessel operations would be improved, allowing fuller loads per vessel and reducing ocean transportation costs.	The additional 2 feet of channel depth would further improve the window of availability for vessel transits, which would provide more increased socioeconomic support to the region. While more entrainment of fish and crabs would occur during the deepening, such impacts to commercial species are expected to be minor. Alternative 3 would have a beneficial effect on the local economy and socioeconomics of the area because vessel operations would be more fully improved, allowing fuller loads per vessel and reducing ocean transportation costs. These beneficial effects would be higher than those under Alternative 2 because of the increased clearance and longer window of availability for vessel transits into and out of the Port.
Environmental Justice Communities	Maintenance dredging of the navigation channel and placement of dredged materials provides economic support to the area by maintaining a navigable channel to the Port of Grays Harbor and related manufacturing facilities. This supports the low-income communities located along the shoreline of Grays Harbor. However, the extent of that support would continue to be limited due to the shoaling, tidal delays, and related constraints on vessels use of the navigation channel when maintained at −36 feet MLLW.	Alternative 2 would not result in disproportionately high or adverse human health or environmental effects on minority and low-income communities, because the channel deepening would not result in any direct impacts on such communities. By deepening the channel 1 foot, Alternative 2 would better support jobs related to the Port facilities, manufacturing and commercial businesses, and recreation that depend on reliable navigation through the harbor.	Alternative 3 would not result in disproportionately high or adverse human health or environmental effects on minority and low-income communities, because the channel deepening would not result in any direct impacts on such communities. By deepening the channel 2 feet, Alternative 3 would better support jobs related to the Port facilities, manufacturing and commercial businesses, and recreation that depend on reliable navigation through the harbor. These beneficial effects would be higher than those under Alternative 2 because of the increased clearance and longer window of availability for vessel transits into and out of the Port.
Indian Treaty Rights	Maintenance dredging overlaps with the latter portion of the tribal gillnetting season (late January to mid-April). Gillnetters may be displaced by the location of the dredging barge in the navigation channel, but would be able to deploy their nets upstream or downstream of the barge and continue fishing. Because gillnets can be deployed to avoid the dredging barge, and the dredging operations are pre-coordinated with the fishers only very minor reductions in fishing efficiency would be experienced under Alternative 1. Vessel traffic during dredging and placement of dredged materials, particularly at open-water sites, has the potential to temporarily affect the activities of Quinault Indian Nation Dungeness crab fishers. Under Alternative 1, the degree and nature of such temporary effects would continue per baseline conditions.	Dredging would require an additional 45 days for the inner harbor reaches, compared to Alternative 1, but the effect mechanisms of Alternative 1 would be the same. Alternative 2 would employ the same methods, dredging equipment, placement sites (with the following exceptions: dredged material for upland mitigation site replenishment would be pumped ashore via submerged/floating hydraulic pipeline moored in Half Moon Bay, a long-reach excavator would be used to remove some material from the Cow Point Reach, material determined to be unsuitable for unconfined aquatic disposal would be transferred and disposed upland, and dredged material would be placed in a shifted Point Chehalis aquatic site during construction of the deepened channel), and schedule, and would be conducted with the same number of dredging vessels and work hours per day as under Alternative 1. Although the duration of disruption to the Quinault Indian Nation fisheries crab fisheries would increase under this alternative and there would be more trips to the placement sites by the barges, the nature of the disruption would not change and the disruptions would remain temporary. Therefore, the potential for impacts on Indian Treaty Rights for these fisheries is expected to be minor.	Dredging would require two clamshell dredges under this alternative however the potential for impacts on Indian Treaty Rights for gillnet and Dungeness crab fisheries is expected to be minor for the same reasons as noted for Alternative 2.

Resource	Alternative 1 (No Action): Continue Channel Maintenance of -36 Feet MLLW	Alternative 2 (Deepen Channel to −37 Feet MLLW)	Alternative 3 (Deepen Channel to −38 Feet MLLW)
Placement Site Environment	The Corps selects among the designated placement sites for any particular volume of sediment based on the source of the dredged material, the depth and capacity of each placement site, the amount of material already present at the placement sites, the capabilities of the contractor's equipment, and weather/wave conditions at the time of placement. Typically, material from the inner harbor reaches is deposited at the South Jetty site, unless there are adverse weather/wave conditions or the South Jetty site is full, in which case placement occurs at the Point Chehalis site. For the outer harbor reaches, some sediment may be deposited at the Half Moon Bay beneficial use site, the Point Chehalis Revetment Extension mitigation site, and the South Beach nearshore nourishment site, with the remainder of the sediment placed in the South Jetty or Point Chehalis sites. The presence of commercial crab pots in a placement site and/or access lane (South Beach), and the amount of material present (Half Moon Bay) are also factors considered for outer harbor reach sediments.	Approximately 1,031,000 cubic yards of additional material would be placed during the construction year. The Half Moon Bay, Point Chehalis Revetment Extension mitigation and South Beach placement sites would be expected to continue to receive material, as needed, to maintain beach nourishment activities, but could receive a larger volume of material if such a need were present during the implementation of Alternative 2. The South Jetty and shifted Point Chehalis sites would receive material, and 13,500 cubic yards would be placed upland. The placement of the dredged material is not expected to alter sediment transport dynamics, including the dynamics of the flood and ebb currents and patterns of shoaling and erosion compared to placement under Alternative 1. Therefore, the effects of this alternative on the placement sites are expected to be minor.	Approximately 1.972 million cubic yards of material would be placed during the construction year. The dredged material would be placed at the same placement sites as under Alternative 2, and 22,400 cy of unsuitable material would be placed upland. The placement of the dredged material is not expected to alter sediment transport dynamics, including the dynamics of the flood and ebb currents and patterns of shoaling and erosion compared to placement under Alternative 1. Therefore, the effects of this alternative on the placement sites are expected to be minor.

6.10 Evaluation of Alternatives with P&G Criteria

Table 28 summarizes evaluation of the three alternatives with the four criteria in *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*, referred to as the Principles and Guidelines (P&G). Completeness is the extent to which an alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planning objectives, including actions by other federal and non-federal entities; Effectiveness is the extent to which an alternative plan contributes to achieving the objectives; Efficiency is the extent to which an alternative plan is the most cost-effective means of achieving the objectives; Acceptability is the extent to which an alternative plan is acceptable in terms of applicable laws, regulations and public policies.

Table 28: Evaluation of Alternatives with P&G Criteria

	Alternative 1 – No Action	Alternative 2 – Deepen Channel to -37 ft MLLW	Alternative 3 – Deepen Channel to -38 ft MLLW
Completeness	No – The No Action alternative does not ensure realization of the planning objective of this limited reevaluation.	Yes – Alternative 2 would ensure realization of the planning objectives of this limited reevaluation, although not to the same extent as Alternative 3, based on the economic analysis summarized in Section 6 above.	Yes – Alternative 3 would ensure realization of the planning objectives of this limited reevaluation, based on the economic analysis summarized in Section 6 above.
Effectiveness	No – The No Action alternative continues current maintenance to -36 ft MLLW and, therefore, does not meet the objective to reduce navigation transportation costs for the existing and project future fleet of deep-draft vessels, and improve efficiency and reliability of navigation to and from Grays Harbor over the 50-year period of analysis as feasible and economically justified.	Yes – Based on the economic analysis conducted for this limited reevaluation, Alternative 2 would meet the objective to reduce navigation transportation costs and improve efficiency and reliability.	Yes – Based on the economic analysis conducted for this limited reevaluation, Alternative 3 would meet the objective to reduce navigation transportation costs and improve efficiency and reliability.
Efficiency	No – Alternative 1 does not meet the objectives of this limited reevaluation and, therefore is not efficient.	No – Although Alternative 2 does meet the planning objective of this limited reevaluation, it does not maximize net benefits, based on the economic analysis conducted for this study and, therefore, is not considered efficient.	Yes - Alternative 3 is efficient because it maximizes net benefits (average annual benefits less average annual cost), based on the economic analysis conducted for this limited reevaluation, and is the plan that maximizes net benefits for National

			Economic Development (NED).
Acceptability	Yes – This alternative is acceptable because it is consistent with applicable laws, regulations and public policies.	Yes – This alternative is acceptable because it is consistent with applicable laws, regulations and public policies.	Yes – This alternative is acceptable because it is consistent with applicable laws, regulations and public policies.

6.11 Summary of Evaluation and Comparison of Alternatives

Table 29 below summarizes the evaluation and comparison of the three alternatives evaluated during this study. NED benefits were developed by comparing the future without-project (No Action Alternative) condition to the future with-project condition (Alternative 2 and Alternative 3). For the economic analysis, the No Action Alternative – as a baseline for comparison - has a BCR of zero (see Appendix A – Economic Analysis). However, the depth of the No Action Alternative (i.e. -36 ft MLLW) does have a BCR based on the 1989 GDM. These 1989 numbers are reflected here under No Action.

Table 29: Summary of Evaluation and Comparison of Alternatives

	Alternative 1	Alternative 2	Alternative 3
	No Action	**Deepen channel to -37 ft MLLW**	**Deepen channel to -38 ft MLLW**
National Economic Development (NED)			
Average Annual Benefits	$43,566,416	$3,661,000	$7,142,000
Average Annual Cost	$23,658,316	$751,000	$1,382,000
NED Benefits		$2,910,000	$5,760,000
Benefit to Cost Ratio	1.84	4.9	5.2
Environmental			
Environmental Effects		• Effects would be minor	• Effects would be minor • Slightly greater effect on natural environment compared to Alternatives 1 and 2 because navigation channel would be dredged to greater depth, but still minor
Other			
Meets Planning Objective	No	Yes	Yes
Response to Planning Constraints	Avoids constraints	Avoids constraints	Avoids constraints
Completeness	No	Yes	Yes
Effectiveness	No	Yes	Yes
Efficiency	No	Yes	Yes
Acceptability	Yes	Yes	Yes

6.12 Selection of Recommended Plan

Based on the economic analysis conducted for this study, the Recommended Plan is Alternative 3: Deepen Channel to -38 feet MLLW. The Recommended Plan maximizes net benefits for National Economic Development (NED) and meets the study objective while avoiding the study constraints. Based on the environmental analysis documented in the SEIS, Alternative 3 is also the preferred alternative. Chapters 7 and 8 provide details of the Recommended Plan and Plan Implementation.

7 Recommended Plan

7.1 Changes to Project Scope

The recommended plan to deepen the navigation channel would not change the legislatively authorized scope of the Grays Harbor NIP. The channel segment that would be deepened to -38 feet MLLW under the recommended plan was authorized in 1986 to a depth of -38 feet MLLW, but was constructed and is implemented to a depth of -36 feet MLLW.

7.2 Changes to Project Purpose

The recommended plan would not change the project purpose of the authorized Grays Harbor NIP, which is a single-purpose navigation project.

7.3 Changes to Project Location

No changes to the project location are proposed. The recommended plan would deepen a segment of the existing navigation channel.

7.4 Design Changes

The recommended plan proposes channel deepening from the current implemented depth of -36 feet MLLW to a project depth of -38 feet MLLW, from South Reach (Station 463+00) to Cow Point (Station 1231+48). Implementation of the recommended plan also includes two feet of advanced maintenance dredging and two feet of allowable overdepth dredging, as defined in the Corps' navigation and dredging regulation policy (ER 1130-2-520). Design changes for the upland placement of material unsuitable for open-water placement are addressed in the Land Requirements section below (8.3).

7.5 Changes to Project Cost, Benefits and Benefit-Cost Ratio

Table 30 below provides a comparison of the project fully funded costs, average annual benefits, average annual costs, and benefit-cost ratios for the authorized project, the implemented project, and the recommended plan. The cost from the May 1985 Chief of Engineers Memo and the 1989 GDM were updated to October 2013 price levels using the current FY14 interest rate of 3.5%. No new authorization is required for the recommended plan as the depth in the recommended plan is already authorized in WRDA of 1986.

Benefits from the recommended plan were derived from the transportation cost savings and reduction in vessel delays associated with vessel movement in and out of the Port of Grays Harbor. When updated, the project cost, annual benefits and annual costs change. The ratios of said updates do not change and, as a result, the resulting BCRs remain the same regardless of the year of analysis.

Table 30: Comparison of Costs, Benefits and BCR of Authorized, Implemented and Recommended Plans

Comparison of Authorized, Implemented, and Recommended Cost, Benefit, and BCR			
	May 1985 Chief of Engineers Memo Authorized -38 ft MLLW (October 1984 Price Levels, 8.375% Interest)	Grays Harbor Navigation Improvement Project 1989 General Design Memorandum (-36 feet MLLW) (October 1988 & 1991 Price Level, 8.625% Interest)	Grays Harbor, Washington, Navigation Improvement Project -38 (Oct 2013 Price Levels, 3.5% Interest)
Project First Cost	$93,187,000	$61,300,000 [7]	$17,945,000
Average Annual Benefits	$15,443,000	$14,045,000	$7,142,000
Average Annual Cost	$11,513,000	$7,627,000	$1,382,000
Benefit to Cost	1.34	1.84	5.2[8]
	May 1985 Chief of Engineers Memo Authorized -38 MLLW (Oct 2013 Price Levels, 3.5% Interest)	Grays Harbor Navigation Improvement Project 1989 General Design Memorandum (Oct 2013 Price Levels, 3.5% Interest)	Grays Harbor, Washington, Navigation Improvement Project -38 (Oct 2013 Price Levels, 3.5% Interest)
Project First Cost	$ 356,474,141	$ 190,147,476	$17,945,000
Average Annual Benefits	$ 59,075,087	$ 43,566,416	$7,142,000
Average Annual Cost	$ 44,041,409	$ 23,658,316	$1,382,,000
Benefit to Cost	1.34	1.84	5.2

7.6 Changes to Cost Allocation

The recommended plan would not change the project purpose of the authorized Grays Harbor NIP, which is a single-purpose navigation project; therefore no changes to cost allocation are required.

7.7 Environmental Considerations in Recommended Changes

For the environmental analysis, the Corps analyzed project-related effects of the three alternatives. The environmental consequences analyses presented in the SEIS determined that the effects would be minor. Based on this analysis, no new compensatory mitigation measures are proposed specifically for the construction or maintenance of the recommended plan. Section 7.8 below describes minimization and avoidance measures the Corps would implement for maintenance of the recommended plan. Considerations for upland placement of unsuitable material are addressed in the placement methods described Section 7.9.1.3 below.

[7] This number was based on October 1988 price levels and was taken from the GDM as the average annual benefit and costs were derived using 1991 price levels also taken from the GDM.
[8] The benefit to cost of the current NIP is subject to change as the fully funded cost has yet to be certified and/or fully developed. However, the cost used for the analysis is not expected to change significantly enough to change the outcome of the NED recommended plan and is considered more than adequate for use in the initial analysis.

7.8 Mitigation

The environmental consequences analysis conducted for this reevaluation (and documented in Chapter 4 of the SEIS, appendix C) shows the potential impact on resources of the recommended plan (i.e. the increment to dredge from -36 feet MLLW to -38 feet MLLW, and subsequent maintenance requirements) would be minor or negligible. Based on this analysis, no new compensatory mitigation measures are proposed specifically for the construction or maintenance of the recommended plan. The potential impact of dredging would be minor to the overall Dungeness crab population based on modeling that was conducted as part of the environmental analysis.

The Corps currently implements the following avoidance and minimization measures in the study area as part of regular maintenance dredging. These same avoidance and minimization measures would be implemented for maintenance of the recommended plan after construction.

- To avoid impacts on bull trout and out-migrating juvenile salmon, the Corps would not dredge the Cow Point Reach, Hoquiam Reach, and turning basins between February 15 and July 15.
- Use a clamshell dredge to reduce entrainment of fish and crabs in the inner harbor reaches.
- Dredge the outer harbor during periods to avoid peak crab abundance.
- Coordinate with local fishers to reduce the potential to damage crab pots.
- Coordinate the timing of dredging to minimize impacts on target species important to Native Americans.
- Place dredged material at Half Moon Bay Nearshore and Upland Placement sites to facilitate a stable beach profile.
- Implement ballast water exchange protocols to avoid and minimize the potential for dredging activities to facilitate the transfer of nonnative and potentially invasive organisms from different estuaries along the Pacific Coast.

The Corps also implements the following avoidance and minimization measures specifically to protect Grays Harbor as an important nursery for juvenile Dungeness crab.

- Schedule dredging to the extent practicable to avoid times and areas of high crab densities.
- Locate offshore placement sites to avoid high concentrations of crabs and interference with the crab fishery.
- Use clamshell dredges instead of hopper dredges wherever possible in order to avoid entraining crabs.
- Continue to implement the 1998 Revised Crab Mitigation Strategy Agreement (RCMSA) (SEIS, Appendix F).

The Corps will also implement the following minimization measures in implementing the project:

- Material that was found unsuitable for open water disposal will be removed in accordance with BMPs, including a smaller allowable turbidity mixing zone, and placed at an upland location, further minimizing any potential impacts to crab and other aquatic species.

7.9 Plan Construction

7.9.1 Dredging Process

Under the recommended plan, project construction (i.e. initial dredging from -36 ft MLLW to -38 ft MLLW), including scheduled work periods, types of equipment, and methods for dredged material placement, would be implemented as per current maintenance dredging, with the following exceptions: dredged material for upland mitigation site replenishment would be pumped ashore via submerged/floating hydraulic pipeline moored in Half Moon Bay, a long-reach excavator would be used to dislodge some hardpack material for removal from the Cow Point Reach, material determined to be unsuitable for unconfined aquatic disposal would be transferred and disposed upland, and dredged material would be placed in a shifted Point Chehalis aquatic site during construction of the deepened channel. Construction would occur concurrently with maintenance dredging in the year the project is implemented. The following section describes timing and methods for dredging during construction and maintenance of the recommended plan.

7.9.1.1 Timing

The dredging schedule varies by reach (Table 17). Dredging occurs between July 16 and February 14 in the Cow Point turning basin, Cow Point, and Hoquiam Reaches, and from 1 August to 14 February in the North Channel and Inner Crossover Reaches. Dredging is scheduled to allow removal of shoals resulting from high river flows in the spring and to avoid salmonid migrations in the spring and early summer. Typically, this dredging operation lasts approximately 4.5 months but could be up to an allowed window of 6 months, depending largely on weather conditions. For the outer harbor reaches, dredging occurs between April 1 and June 30 in South Reach, and the Outer Crossover is dredged 1 April to 31 May if a hopper dredge is utilized or 1 August to 14 February if a clamshell dredge is used. The duration of maintenance dredging can vary year to year, but is typically about 1 month. Dredging is scheduled for this time to coincide with favorable weather/wave conditions and to reduce impacts on the Dungeness crab fishery. Therefore, throughout the year dredging and placement of dredged materials are not occurring during two periods: February 15 through March 31 and July 1 through July 15.

7.9.1.2 Dredged Material Placement Method/Equipment - Nearshore and Upland Nourishment Sites

The Corps uses two methods to dredge the navigation channel. The first method is a mechanical or “clamshell” dredge, which is used to dredge the inner harbor reaches (including the entire Crossover reach, however, a hopper dredge may still be used in the Outer Crossover reach when necessary). Clamshell dredges include use of a tugboat and two barges, one to support the clamshell derrick and the other a bottom-dump barge for storage and transport of the dredged material to the placement site. Under baseline conditions (Alternative 1), one tugboat is used to position one clamshell dredge (on a barge) and one bottom-dump barge is used to transport material in order to complete the inner harbor dredging.

Use of a clamshell dredge has been well documented to greatly reduce both entrainment and mortality of crab and other aquatic species when compared to a hopper dredge (Armstrong et al 1987, Dumbauld et. al. 1988). Clamshell dredging is used exclusively in the Inner reaches (inner Cross-Over Reach and inward) to reduce entrainment of fish, shrimp, and crabs in the inner harbor reaches. For the outer half of the Cross-over Reach clamshell use is emphasized and preferred, however this reach can be dredged with either hopper dredge or clamshell. The clamshell bucket proceeds from the outer edges of the navigation channel, across the channel to the other bank and then back, dredging progressively until the desired depth is achieved. This method of dredging, along with the mild angle of the channel’s side slopes (e.g., 1V:5H in South Reach, steepening to 1V:3H beginning at the North Channel), leaves the channel width substantially unchanged and minimizes the potential for sloughing/avalanching of sediment from the channel’s side slopes after dredging is completed.

The other method uses a hydraulic hopper dredge for the reaches in the outer harbor. The hopper dredge is able to dredge material, store it onboard, transport it to a placement area, and deposit it. Two government hopper dredges “Essaysons” and “Yaquina” have annual assignments in Grays Harbor to perform outer harbor maintenance dredging. Hopper dredges are better suited for use in the more exposed outer harbor reaches, because clamshell dredges must be rafted together with a scow barge, which can be hazardous in choppy seas. Sediments removed from the outer harbor reaches are primarily sands of marine origin that are extracted using a hopper dredge. These heavy particles settle out of suspension rapidly and generally do not disperse to adjacent areas (U.S. Army Corps of Engineers 2011). Use of a hopper dredge also reduces suspension of these heavier sediments.

The hydraulic hopper dredge typically cuts from the toe of the sideslope outward, maximizing the bank height to achieve greater production rates. The mild angle of the channel’s side slopes minimizes the potential for sloughing/avalanching of sediment from the side slopes after dredging is completed.

The Point Chehalis Revetment Extension mitigation site will be recharged with dredged material from a hopper dredge with hydraulic pump-ashore capability. The hopper will dredge sand from the navigation channel and transit to a mooring dolphin within Half Moon Bay and hydraulically pump dredged material via a floating or submerged pipeline into the stockpile site. The sandy dredged material would quickly dewater and a bulldozer would grade the sand uniformly over the placement area. The slurry of water and sand would temporarily pond in the placement site as the dredged sediments settle out of suspension, and decant water would be conveyed via effluent pipe into Grays Harbor at the exposed rock revetment near Groin A. A water quality monitoring plan would be implemented in accordance with an approved Water Quality Certification issued by Ecology. Material placed above MHHW in the Point Chehalis Revetment Extension mitigation site is expected to subsequently erode through natural processes, with portions of the material entering the intertidal zone and thus the littoral system.

7.9.1.3 Dredged Material Placement Method/Equipment – Upland Placement During Construction for Material Unsuitable for Open-Water

Material dredged during construction that is unsuitable for open-water placement would be clamshell dredged for removal. Implementation of best management practices – such as control of the speed of the dredging bucket during descent and ascent – and compliance with the water quality monitoring plan will ensure that turbidity is reduced to the maximum extent possible during dredging. Dredged material would be placed in a fully fenced haul barge where it will be dewatered through filtered scuppers to control turbidity in water returning to Grays Harbor. Contaminants are generally associated with the sediment itself and with suspended sediment particles in the water column. By minimizing the loss of suspended particles during dewatering, loss of any chemical contaminants associated with the sediment will also be minimized. The dredged material would be taken by barge to be offloaded at nearby Port of Grays Harbor Terminal 3 (a distance of less than 4 miles) and trucked the short distance to the former Hoquiam city wastewater treatment lagoon for offload (less than half-a-mile), and dumped from the transport trucks directly into the offload site. The dewatered dredged material would be mechanically transferred from the barge to trucks using an excavator or front load excavator. The lagoon is a former wastewater treatment pond formerly utilized by the city of Hoquiam for treatment of municipal sewage. The methodology for placing the material is expected to consist of dredging via clamshell dredge and barge with mechanical rehandling of material on land. During dredging the barge would be lined with geotextile fabric to prevent leakage. The barge would be transported to Port of Grays Harbor Terminal 3 and dewatered through a sump pump with a geofabric bag surrounding the discharge pipe to contain sediments. Land-based equipment would be used to transfer and transport the dewatered dredged material from the barge to the placement area along the southern edge of the former waste water treatment lagoon, as depicted in Figure 16.

DMMU subunit 32a would be physically surveyed after construction, and a determination would be made at that time whether an additional round of testing is required of that subunit prior to any subsequent maintenance dredging episode in that subunit's footprint.

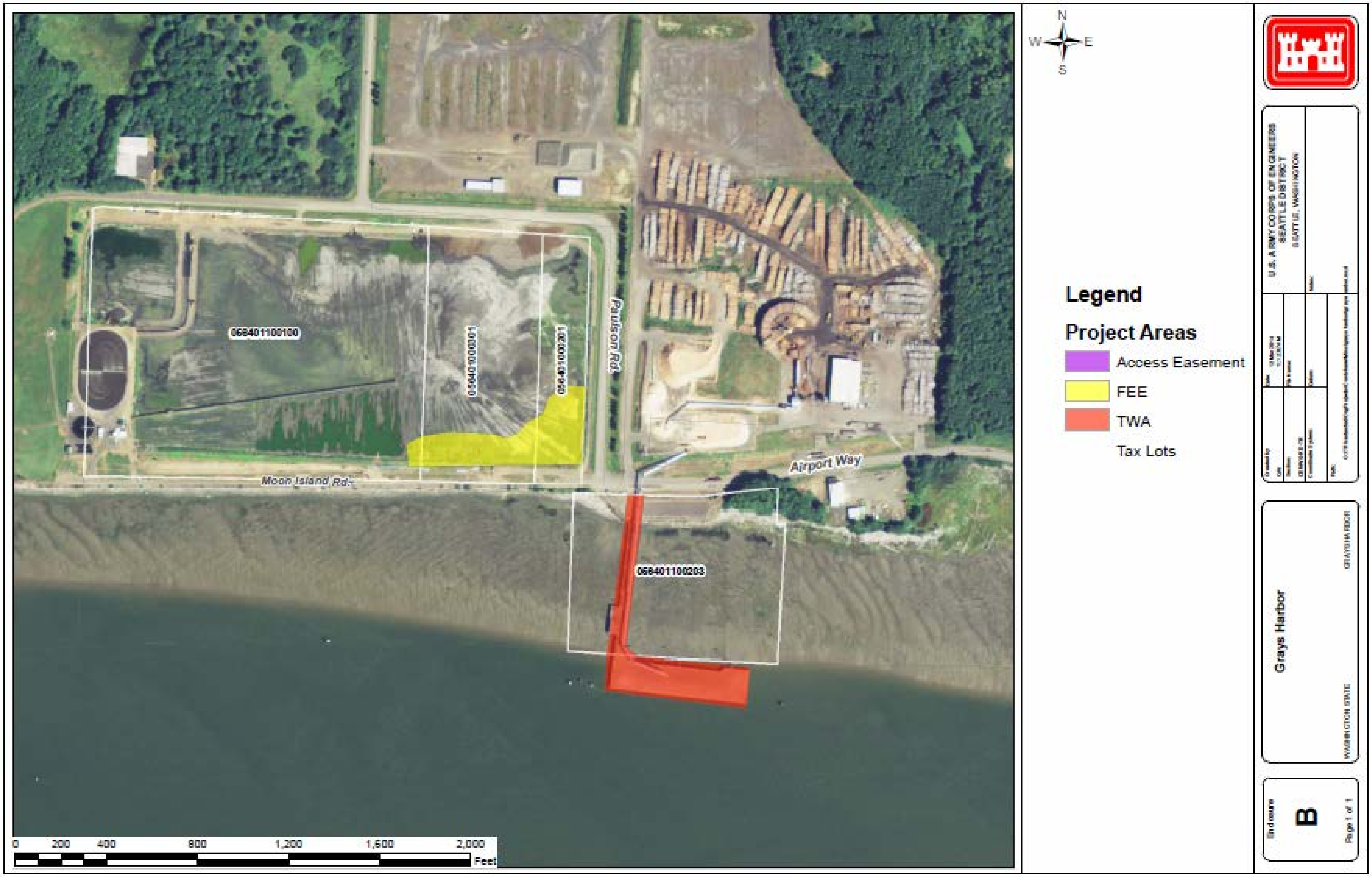

Figure 17: City of Hoquiam Wastewater Treatment Lagoon, Located Near Port of Grays Harbor Terminal 3, for Recommended Plan (Alternative 3)

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7.10 Placement Sites

Placement of the material dredged from the navigation channel occurs only at designated placement sites. Figure 18 illustrates the location of all dredged material placement sites. Two Washington State Department of Natural Resources (DNR) public, multi-user, unconfined open-water dredged material placement sites are located directly adjacent to the navigation channel: the South Jetty and the Point Chehalis placement sites. Both sites are located on state-owned aquatic lands and managed by Washington DNR. In addition, material dredged from the sandy outer harbor reaches of the channel is periodically used for both direct upland placement at the Point Chehalis Revetment Extension mitigation site (when feasible) and nearshore nourishment at the Half Moon Bay beneficial use site and nearshore nourishment at the South Beach beneficial use site. Material placed above MHHW in the Point Chehalis Revetment Extension mitigation site is expected to subsequently erode through natural processes, with portions of the material entering the intertidal zone and thus the littoral system. The Point Chehalis site overlaps the navigation channel however, the dispersive nature of this site effectively transports material out of the site boundaries and has historically provided sufficient capacity for annual O&M dredged material.

Determination of sites: The determination of which placement site is used during the course of maintenance dredging is based on a variety of factors. For both the inner and outer harbor reaches, placement is determined based on the source of the dredged material, the depth of each aquatic placement site, the amount of material already present at the placement sites, and weather/wave conditions at the time of placement. For the inner harbor reaches, material is typically deposited at the South Jetty site, unless there are adverse weather/wave conditions or the South Jetty site is full, in which case placement typically occurs at the Point Chehalis open water placement site. For the outer harbor reaches, some of the dredged materials may be deposited at three beneficial use sites: the Half Moon Bay nearshore nourishment site, the Point Chehalis Revetment Extension Site, and the South Beach nearshore nourishment site. Remaining material is typically placed in the South Jetty or Point Chehalis sites. Factors that determine which placement sites are used for the outer harbor reaches include the presence of commercial crab pots in a placement site and/or access lane (for South Beach), the amount of material present (for Half Moon Bay), as surveyed annually, and results of pre-disposal Dungeness crab surveys (for both Half Moon Bay and South Beach).

NWS is pursuing a one-time shift of the Point Chehalis site boundary to provide adequate capacity for the large volume of material that would be dredged for construction of the recommended plan - some of which is anticipated to be cohesive material. The basis for pursuing this shift is a 2012 analysis by the USACE Engineer Research and Development Center that recommended shifting the Point Chehalis placement site 1,000 feet to the north-northwest to take advantage of deeper water and more dispersive hydrodynamics (Figure 18).

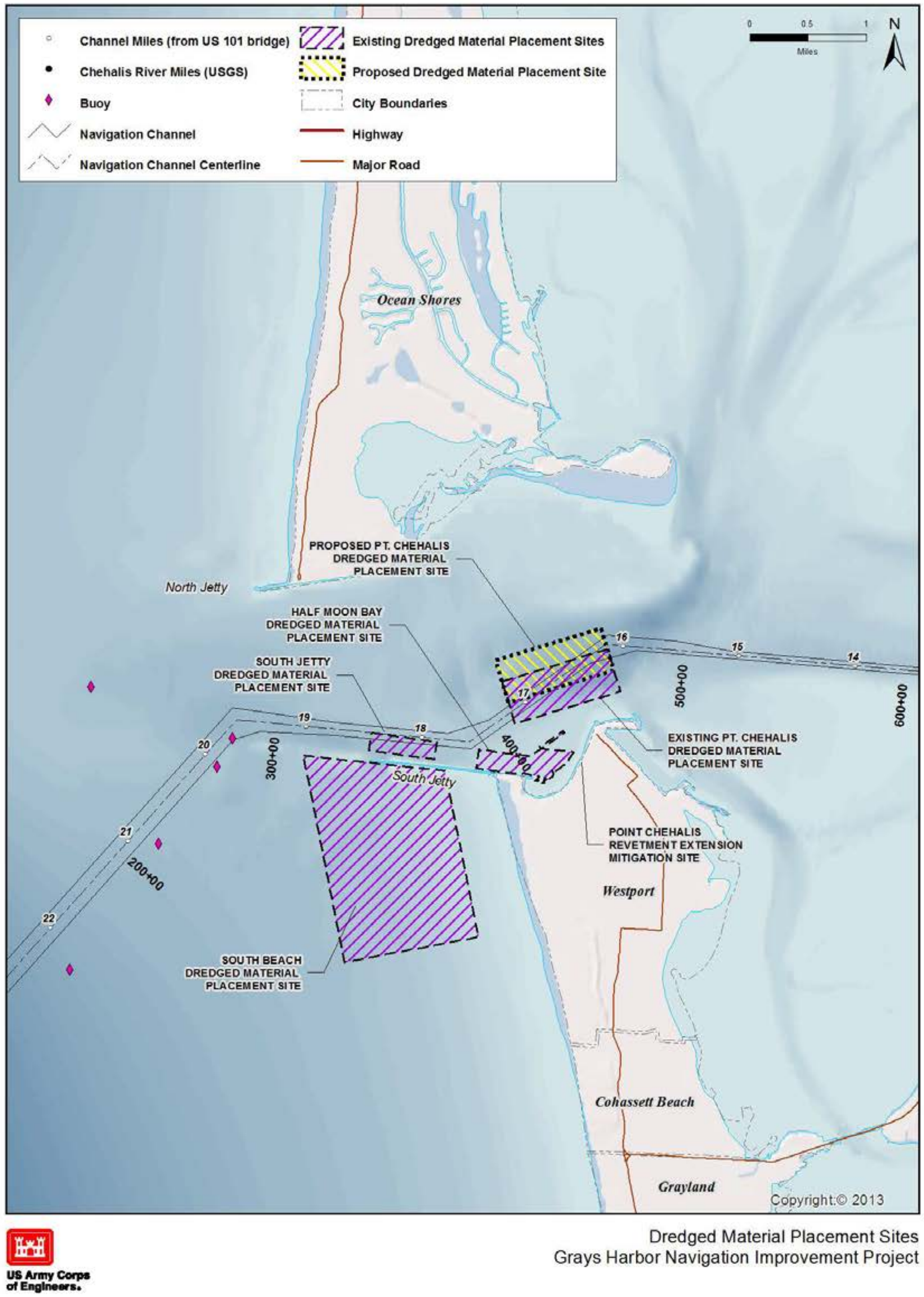

Figure 18: Open-Water Placement Sites and Point Chehalis Placement Site Shift for Recommended Plan (Alternative 3)

7.11 Cost Estimate

The fully funded current cost estimate to construct the recommended plan is $18.444 million. The additional volume of material that would be dredged during subsequent operation and maintenance of the recommended plan (107,000 cy) would be an incremental increase above the current O&M volume. The O&M cost of the increment from -36 feet MLLW to -38 feet MLLW would be approximately $0.590 million annually.

Guidance for preparation was obtained from ER 1110-2-1150 Engineering and Design (E&D) for Civil Works Projects, ER 1110-1-1300 E&D Cost Engineering Policy and General Requirements, ER 1110-2-1302 Civil Works Cost Engineering, and ETL 1110-2-573 E&D Construction Cost Estimating Guide for Civil Works. The cost estimates were prepared using Micro-Computer Aided Cost Estimating System MII version 4, build 4. Supporting cost libraries or databases were MII 2012-b English Cost Book, 2011 Region VIII Equipment library (EP 1110-1-8) and the 2013 Davis-Bacon Wage Rates for heavy construction in Grays Harbor County, Washington.

The basis of the cost estimate is the conceptual design drawings prepared by the Project Delivery Team (PDT). Dredging quantities were provided by the Costal Engineering Section. Additional information has been developed by the PDT via emails, phone calls, and in-person discussions. The MII cost estimate carefully documents the basis of information used in development of costs, down to the lowest reasonable level.

The major features of work include two types of dredging: clamshell dredging and hopper dredging. All clamshell dredging costs were developed using the most current version of the Corps of Engineers Dredge Estimating Program (CEDEP). All hopper dredging costs were developed using the FY14 daily rate and production rates of the Government Hopper Dredge Yaquina. The PDT assumed that the hopper dredging would be done via government vessel and the Yaquina is the most conservative of the options available.

Risk and uncertainties are captured in the Cost and Schedule Risk Analysis (CSRA). PDT input was used to capture the likelihood and impact for each risk element. The CSRA assigns a contingency to all features of work in the cost estimate. The cost estimate and its corresponding contingency were then placed into the Total Project Cost Summary and the proper escalation factors were applied. See Appendix E for the Total Project Cost Summary.

7.12 Section 902 Cost Limitation

A 902 calculation was performed on the Grays Harbor Navigation Improvement Project in June 2014 to verify current and projected costs of the authorized project will not exceed the maximum allowable cost by Section 902. The project was authorized in WRDA 1986 for $95.7 million at an authorized depth of -38 MLLW. To date, the project has only been maintained to -36 MLLW and this Limited Reevaluation Report examined the economic justification in dredging to the authorized depth. A total of $29.7 million was allocated through fiscal year (FY) 2013, with $26.2 million allocated to construction and $3.5 million allocated to real estate. The cost estimate for the additional 2 feet of dredging to the authorized depth is estimated at $17.3 million, bringing the current cost estimate of the authorized project to $43.5 million. The current cost estimate inflated through construction is $47.5 million.

The 902 calculation used the certified Corps spreadsheet tool to generate Tables G-1 to G-4 in Appendix G of the Planning Guidance Notebook (ER 1105-2-100). Inputs to the model included the authorized cost, date of authorization, first year of expenditure, current cost estimates (construction and real estate), and the current fully funded cost estimate. Two sets of indices are used in the 902 calculation: 1) Civil Works Construction Cost Index System for Navigation Ports and Harbors (EM 1110-2-1304, updated 30 September 2013); and 2) the Unadjusted Consumer Price Index (All Urban Consumers – US City Average) for real estate costs. Allocated costs for construction and real estate were input by fiscal year as shown in Table x.

Table 31 is Table G-4 generated using the 902 tool. The authorized cost at current price levels is $146 million, or $160 million inflated through construction. Cost estimates are not allowed to exceed more than 20 percent of the authorized cost limit. Currently the 902 limit for this project is estimated at $179 million (see Line 4 of Table G-4). The current project cost estimate inflated through construction is $47.5 million (see Line 1 of Table G-4), which is well below the computed 902 limit of the project. At this time, the project has low risk of approaching or exceeding the 902 limit.

Table 31: Maximum Cost of Grays Harbor NIP, Including Inflation, Through Construction

Table G-4 (ER 1105-2-100 Appendix G)		
MAXIMUM COST INCLUDING INFLATION THROUGH CONSTRUCTION		
FY 13	-	**Thousands Dollars (000's)**
Line 1		
a.	Current Project estimate at current price levels:	$43,529
b.	Current project estimate, inflated through construction:	$47,507
c.	Ratio: Line 1b / line 1a	1.0914
d.	Authorized cost at current price levels:	$146,145
	(Column (h) plus (i) from table G-3)	
e.	Authorized cost, inflated through construction:	$159,501
	(Line c x Line d)	
Line 2	Cost of modifications required by law:	$0
Line 3	20 percent of authorized cost:	$19,140
	.20 x (table G-3, columns (f) + (g)	
Line 4	Maximum cost limited by section 902:	$178,641
	Line 1e + line 2 + line 3	

8 Plan Implementation Requirements

This chapter defines implementation responsibilities necessary to ensure the Recommended Plan's goal and objective are achieved.

8.1 Cost Sharing

Table 32 below shows general cost share guidance applicable to the recommended plan, per ER 1105-2-100:

Table 32. General Cost Share Guidance Applicable to Recommended Plan

Local Sponsor Share of Construction	
Project Depth	20 to 45 feet
General Navigation Feature*	25/10%**
Mitigation	25/10%**
Aids to Navigation	0%
Service Facilities	100%
LERRD & Associated Cost***	100%

* GNF costs for this project include: mobilization/demobilization, all dredging costs, all disposal area construction costs
** The second 10% is the amount of total cost of general navigation features and mitigation that the local sponsor must pay over a period not to exceed 30 years. This amount may be offset by the value of LERRD.
***Associated costs are dredging of port berthing area; port infrastructure construction; lands, easements, right of ways, relocations, and acquisition of disposal areas; all utility relocations; costs for features requested by the port in excess of NED.

Table 33 shows the federal and non-federal project first costs of the recommended project, at current price levels.

Table 33: Cost Share Summary

Description	Total	Federal	Non-Federal
General Navigation Features (between -20FT and -45FT MLLW; 75%/25% Federal/Non Federal)	$16,814,000	$12,611,000	$4,204,000
LERR (100% Non Federal)	$509,000	$0	$509,000
Project Cost Apportionment	**$17,323,000**	**$12,611,000**	**$4,713,000**
10% over time adjustment (less LERR)*		($1,172,000)	$1,172,000
Final Distribution of Costs	**$17,323,000**	**$11,439,000**	**$5,885,000**
*10% over time adjustment [$16,814,000 * .10 = $1,681,000 - $509,000 = $1,172,000]			

8.2 Financial Analysis of Non-Federal Sponsor's Financial Capabilities

A financial analysis is required for any plan being considered for USACE implementation that involves non-Federal cost sharing. The purpose of the financial analysis is to ensure that the non-Federal sponsor understands the financial commitment involved and has reasonable plans for meeting that commitment. The financial analysis includes the non-Federal sponsor's statement of financial capability, the non-Federal sponsor's financing plan, and the assessment of the sponsor's financial capability. A self-certification of financial capability signed by the Chief

Financial Officer of the non-Federal Sponsor is required and will be provided with submittal of the final LRR and SEIS to NWD for approval.

8.3 Land Requirements

Upland Placement of Unsuitable Material During Construction. As noted above, approximately 22,400 cubic yards of sediment that will be dredged during construction of the recommended plan from the Cow Point 32a subunit are unsuitable for open-water disposal and would require fee interest in an appropriate upland disposal site. The PDT and Port have identified the City of Hoquiam’s Waste Water Treatment Plant (WWTP) as the upland site within the immediate vicinity of the Port for the unsuitable dredging material disposal during construction. Unsuitable material resulting from subsequent maintenance dredging is not anticipated at this time. As noted earlier in this document, DMMU subunit 32a would be physically surveyed after construction, and a determination would be made at that time whether an additional round of testing is required of that sub-unit prior to any subsequent maintenance dredging episode in that sub-unit's footprint. If it is determined that there is additional unsuitable material that must be dredged and disposed during the subsequent maintenance dredging episodes, the material will be placed at the WWTP. If the WWTP is no longer available, then a similar appropriate upland site will be identified at that time. Current assumptions of land requirements include:

- Initial construction by the Corps' contractor would utilize the Federal Navigational Servitude for dredging and open-water placement activities within the harbor. The Federal Navigational Servitude is available throughout Grays Harbor up to the MHHW tidal elevation.
- Fee interests at the City of Hoquiam's wastewater treatment plant lagoon (WWTP) will be required for upland disposal for unsuitable materials, as well as a temporary work area (TWA) easement for the NFS’ dock that would be used as a barge off-loading facility for dredged materials during the initial construction effort.
- The road separating the Port’s dock from the upland City of Hoquiam’s WWTP disposal site, Moon Island Road/Airport Way, is a public road right-of-way; therefore, trucks transporting dredged materials from the barge off-loading facility to the disposal site would not require any additional easements, or permits to drive on/across the public road between the dock/off-loading facility and the WWTP disposal site.

Maintenance Dredging: Maintenance dredging for the proposed project would require use of an open-water disposal site.

Cost: Table 34 identifies the cost estimates for lands and is based on the Land Cost Estimate (LCE) prepared by Seattle District Real Estate Division, dated 17 April 2014.

Table 34: Baseline Cost Estimate for Real Estate (BCERE)

Estate	Acres	Estimated Land Cost	NFS LERRD Admin	Fed LERRD review & assistance	NFS LERRD Total

Fee for construction disposal (WWTP)	3.38	$441,699	$5,000	$10,000	$458,071
Temporary Work Area (Port dock for offloading– 1yr term)	3.81	$1,372			
Subtotals		$443,071	$5,000	$10,000	$458,071
15% contingency		$66,460	$750	$1,500	$68,710
Project Totals	7.19	$509.531	$5,750	$11,500	$526.781
Totals (rounded)	7.19	$510,000	$5,750	$11,500	$527,000

8.4 Changes in Local Cooperation Requirements

By a Local Cooperation Agreement (LCA) dated 16 February 1990, the Government and the non-federal sponsor (the Port) agreed to cooperate in the modification of the Grays Harbor navigation channel to implement the Grays Harbor NIP, based on the project description in the 1989 GDM. The proposed work in the recommended plan in this LRR requires execution of a Project Partnership Agreement (PPA) because the recommended plan would involve changes to the navigation channel depth, placement (during construction) of material unsuitable for open-water placement, and changes to the project cost. Cost sharing for construction of the GNF would be 25% percent non-federal, with an additional 10% percent in a cash contribution payable over 30 years that may be offset by the value of LERRD. The Corps would construct and maintain the recommended plan.

9 Public Involvement

The PDT has conducted several public involvement activities since initiating this study in 2011, to inform the public and seek input and feedback from interested parties. Table 35 below summarizes these activities.

Table 35: Grays Harbor NIP, Feasibility Study Public Involvement Activities

Date	Action
5 Dec 2012	The Corps and Port conducted a public information meeting on 5 December 2012 at the Port offices to share with the public the current study status, scope and process at that time. No written comments submitted; only a few clarifying questions asked during meeting.
27 Sep 2012, Marysville 20 Nov 2012, NWS 9 Jul 2012, Aberdeen 28 Feb 2013, NWS 25 April 2013, NWS	Crab Working Group meetings to discuss potential impacts of further deepening navigation channel and potential mitigation strategies if potential impacts require mitigation. Primary participants include: Corps, U.S. Fish and Wildlife Service, Washington Department of Ecology, Washington Department of Fish and Wildlife, Quinault Indian Nation, National Marine Fisheries Service, U.S. Environmental protection Agency, Port of Grays Harbor.
7 Jul 2011, NWS 11 Jul 2013, NWS	Dredged Material Management Program (DMMP) meetings. DMMP is an interagency approach to the management of dredged material in the state of Washington. Two federal and two state agencies, all with roles in the oversight of dredging and disposal, cooperate to streamline dredged material evaluation and regulation. Seattle District, U.S. Army Corps of Engineers acts as the lead agency. Cooperating agencies are Region 10 of the U.S. Environmental Protection Agency (EPA), Washington Department of Ecology, and Washington Department of Natural Resources. These meetings focused on the sediment suitability and characterization analyses conducted for this study.
27 Feb 2014, Aberdeen	The Corps conducted a public information meeting during the public comment period on the draft SEIS, to present the PDTs recommended plan and to provide opportunity for public comment on the draft LRR and draft SEIS.

10 Conclusions

The economic analysis summarized in this LRR and documented in Appendix A shows there is economic justification for deepening the navigation channel. The recommended plan, based on the economic and environmental analyses conducted for this reevaluation, is Alternative 3: Deepen Channel to -38 feet MLLW. Alternative 3 maximizes net benefits (benefits less cost) and is the plan that maximizes net benefits for National Economic Development (NED). The NED Plan is the federal recommended plan.

The depth in the recommended plan is the legislatively authorized project depth and no additional congressional authorization would be required to implement the recommended plan. The recommended plan is for a project depth that Congress authorized in 1986, but which was not implemented based on post-authorization analyses conducted in 1989.

The recommended plan to dredge the channel to -38 feet MLLW would reduce transportation costs and allow for more efficient navigation in Grays Harbor by alleviating tidal delays and light loading of the vessel fleet, which is currently caused by insufficient channel depths at all tidal stages.

The fully funded current cost estimate to construct the recommended plan is $18.444 million. The O&M cost of the increment from -36 feet MLLW to -38 feet MLLW would be approximately $0.590 annually. Average annual benefits would be $7,142,000, average annual costs of $1,382,000, NED benefits of $5,760,000, and a BCR of 5.2.

The Government and non-federal sponsor (Port of Grays Harbor) would sign a Project Partnership Agreement.

11 Recommendation

I have considered all significant aspects of this project, including environmental, social and economic effects; and engineering feasibility. I recommend that the existing Grays Harbor, Washington, Navigation Improvement Project (NIP), authorized by WRDA 1986 and as implemented pursuant to the 1989 GDM, be modified generally as described in this report as the Recommended Plan. As the District Engineer, I recommend this plan with such modifications thereof as in the discretion of the Commander, Headquarters, U.S. Army Corps of Engineers, may be advisable. The fully funded current cost estimate to construct the recommended plan is $18.444 million. The O&M cost of the increment from -36 feet MLLW to -38 feet MLLW would be approximately $0.590 annually.

These recommendations are made with the provision that the exact amount of the non-Federal contribution shall be determined in accordance with the following required items of cooperation which the non-Federal sponsor (Port of Grays Harbor) shall agree to perform. These are the major categories of local cooperation. Detailed requirements will be spelled out in the project partnership agreement prior to project implementation:

a. Provide, during the period of design, 25 percent of design costs allocated by the Government to commercial navigation in accordance with the terms of a design agreement entered into prior to commencement of design work for the project; and provide, during the first year of construction, any additional funds necessary to pay the full non-Federal share of design costs allocated by the Government to commercial navigation in accordance with the cost sharing as set out in paragraph b., below;
b. Provide, during construction, 10 percent of the total cost of construction of the general navigation features attributable to dredging to a depth less than 20 feet (which include the construction of land-based and aquatic dredged material disposal facilities that are necessary for the disposal of dredged material required for project construction, operation, or maintenance and for which a contract for the federal facility's construction or improvement was not awarded on or before October 12, 1996); plus 25 percent of the total cost of construction of the general navigation features attributable to dredging to a depth in excess of 20 feet but not in excess of 45 feet;;
c. Pay with interest, over a period not to exceed 30 years following completion of the period of construction of the project, up to an additional 10 percent of the total cost of construction of the general navigation features. The value of lands, easements, rights-of-way, and relocations provided by the non-Federal sponsor for the general navigation features, described below, may be credited toward this required payment. If the amount of credit exceeds 10 percent of the total cost of construction of the general navigation features, the non-Federal sponsor shall not be required to make any contribution under this paragraph, nor shall it be entitled to any refund for the value of lands, easements, rights-of-way, and relocations in excess of 10 percent of the total cost of construction of the general navigation features;

d. Provide all lands, easements, and rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on lands, easements, and rights-of-way to enable the disposal of dredged or excavated material all as determined by the Government to be required or to be necessary for the construction, operation, and maintenance of the project;
e. Accomplish all removals determined necessary by the Federal Government other than those removals specifically assigned to the Federal Government;
f. Provide, operate, maintain, repair, replace, and rehabilitate, at its own expense, the local service facilities to accommodate the fleet facilitated by the recommended project in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and State laws and regulations and any specific directions prescribed by the Federal Government. ;
g. Shall not use funds from other Federal programs, including any non-Federal contribution required as a matching share therefor, to meet any of the non-Federal obligations for the project unless the Federal agency providing the Federal portion of such funds verifies in writing that expenditure of such funds for such purpose is authorized
h. Shall prepare and implement a harbor management plan that incorporates best management practices to control water pollution at the project site and to coordinate such plan with local interests;
i. Comply with all applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended (42 U.S.C. 4601-4655), and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way required for construction, operation, and maintenance of the project, including those necessary for relocations, the borrowing of materials, or the disposal of dredged or excavated material; and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act;
j. Give the Federal Government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-federal sponsor owns or controls for access to the project for the purpose of completing, inspecting, operating, maintaining, repairing, rehabilitating, or replacing the project;
k. Hold and save the United States free from all damages arising from the construction, operation, maintenance, repair, rehabilitation, and replacement of the project and any betterments, except for damages due to the fault or negligence of the United States or its contractors;
l. Keep and maintain books, records, documents, or other evidence pertaining to costs and expenses incurred pursuant to the project, for a minimum of 3 years after completion of the accounting for which such books, records, documents, or other evidence are required, to the extent and in such detail as will properly reflect total project costs, and in accordance with the standards for financial management

systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments at 32 Code of Federal Regulations (CFR) Section 33.20;

m. Comply with all applicable Federal and State laws and regulations, including, but not limited to: Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d) and Department of Defense Directive 5500.11 issued pursuant thereto; Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army"; and all applicable Federal labor standards requirements including, but not limited to, 40 U.S.C. 3141- 3148 and 40 U.S.C. 3701 – 3708 (revising, codifying and enacting without substantial change the provisions of the Davis-Bacon Act (formerly 40 U.S.C. 276a et seq.), the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 et seq.), and the Copeland Anti-Kickback Act (formerly 40 U.S.C. 276c et seq.);
n. Perform, or ensure performance of, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Public Law 96-510, as amended (42 U.S.C. 9601-9675), that may exist in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for construction, operation, and maintenance of the project. However, for lands that the Federal Government determines to be subject to the navigation servitude, only the Federal Government shall perform such investigations unless the Federal Government provides the non-federal sponsor with prior specific written direction, in which case the non-federal sponsor shall perform such investigations in accordance with such written direction;
o. Assume, as between the Federal Government and the non-federal sponsor, complete financial responsibility for all necessary cleanup and response costs of any hazardous substances regulated under CERCLA that are located in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for construction, operation, and maintenance of the project;
p. To the maximum extent practicable, perform its obligations in a manner that will not cause liability to arise under CERCLA; and
q. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended (42 U.S.C. 1962d-5b), and Section 103(j) of the Water Resources Development Act of 1986, Public Law 99-662, as amended (33 U.S.C. 2213(j)), which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until each non-Federal interest has entered into a written agreement to furnish its required cooperation for the project or separable element.
r. In the case of a deep-draft harbor, provide 50 percent of the excess cost of operation and maintenance of the project over that cost which the Secretary

determines would be incurred for operation and maintenance if the project had a depth of 45 feet;

s. Provide a cash contribution equal to the non-Federal cost share of the project's total historic preservation mitigation and data recovery costs attributable to commercial navigation that are in excess of 1 percent of the total amount authorized to be appropriated for commercial navigation.

Date: 23 JUN 2014

BRUCE A. ESTOK
Colonel, Corps of Engineers
Commander and District Engineer

"The recommendations contained herein reflect the information available at this time and current Departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national Civil Works construction program or the perspective of higher review levels within the Executive Branch. Consequently, the recommendations may be modified before they are transmitted to the Congress as proposals for authorization and implementation funding. However, prior to transmittal to the Congress, the sponsor, the states, interested Federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further."

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US Army Corps of Engineers®
Seattle District

Port of Grays Harbor
On Washington's Pacific Coast

Grays Harbor, Washington
Navigation Improvement Project
General Investigation Feasibility Study

FINAL Limited Reevaluation Report

Appendix A: Economic Analysis

Prepared by:

U.S. Army Corps of Engineers
Seattle District

June 2014

Grays Harbor, Washington, Navigation Improvement Project
Grays Harbor County, Washington
FINAL Limited Reevaluation Report
Appendix A: Economic Analysis

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Acronyms

AAEQ	Average Annual Equivalent
ATB	Articulated Tug Barge
BNSF	Burlington Northern Santa Fe Railroad
BLT	Bulk Loader Tool
DDVOC	Deep-draft Operating Cost
FY	Fiscal year
IDC	Interest During Construction
LRR	Limited Reevaluation Report
NED	National Economic Development
MCF	Marine Cargo Forecast
MLLW	Mean Lower Low Water
Port	Port of Grays Harbor
RO RO	Roll on, roll off
sq ft	square feet
UP	Union Pacific Railroad
USACE	U.S. Army Corps of Engineers
CAGR	Compound Annual Growth Rate
NIP	Navigation Improvement Project

1 Introduction

*"The **role** of the U. S. Army Corps of Engineers with respect to navigation is to provide safe, reliable, and efficient waterborne transportation systems (channels, harbors, and waterways) for movement of commerce, national security needs, and recreation. The Corps accomplishes this mission through a combination of capital improvements and the operation and maintenance of existing projects."*(U.S. Army Corps of Engineers 2000)

1.1 Location

The Port of Grays Harbor is located at the mouth of the Chehalis River on the southwestern coastline of Washington (Figure 1), approximately 110 miles south of the entrance to the Strait of Juan de Fuca and 45 miles north of the Columbia River's outfall. The cities of Aberdeen, Hoquiam, Ocean Shores, and Westport are located within the large harbor. Twin jetties secure the mouth of the bay with a deep draft channel over 23 miles long from the Pacific Ocean near Westport inland to Cow Point (near Aberdeen). The two jetties are 17,200 feet and 13,734 feet long (north and south, respectively) and made of large armor rock. The deep draft channel is 1,000 feet wide over the entrance bar and through the entrance channel reach and decreases to 350 feet wide near the Port of Grays Harbor terminals at Cow Point. The channel and jetties were authorized under the River and Harbor Act of 1896, and modified by subsequent acts.

The segment that is being evaluated for deepening is from South Reach inland to Cow Point. This segment of the navigation channel is currently authorized to -38 feet MLLW, but was implemented and is maintained at -36 feet MLLW (Figure 2: Grays Harbor Navigation Channel Reaches) Referenced to other major Northwest Region ports, the port is located approximately 160 nautical miles from the Port of Portland, 280 nautical miles from the Port of Seattle, and 300 nautical miles from the Port of Tacoma (Google Earth Pro 2012).

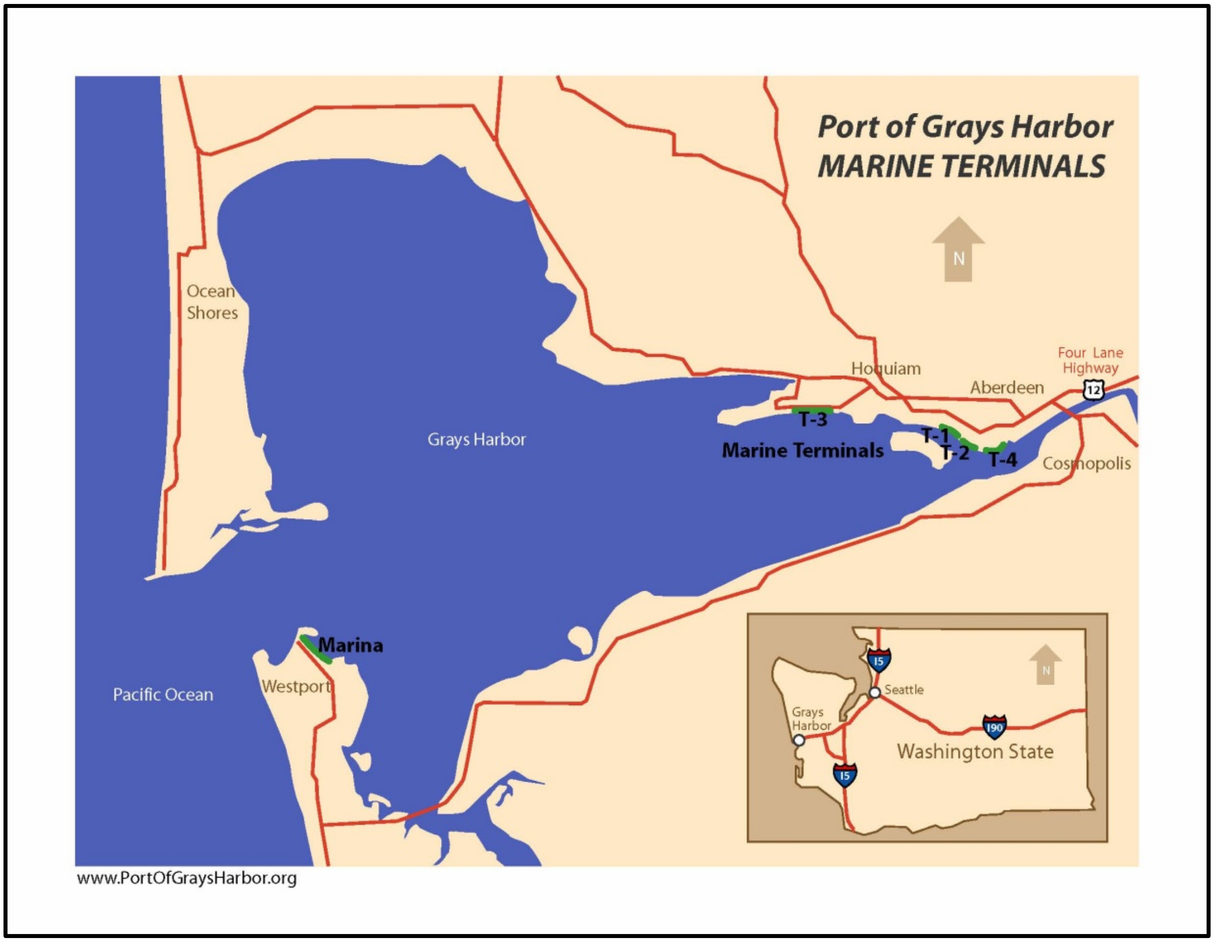


Figure 1: Vicinity Map (Port of Grays Harbor 2013)

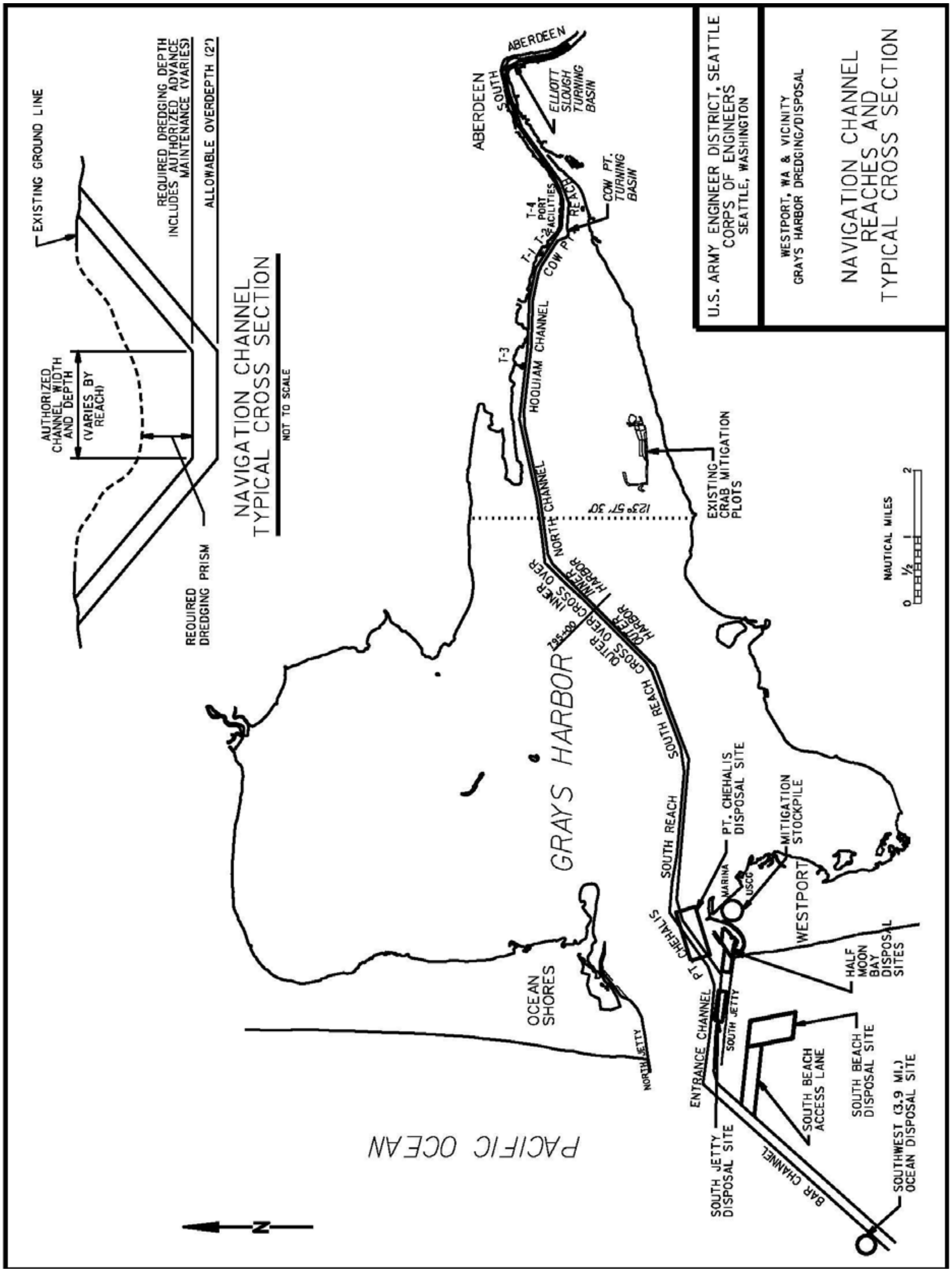


Figure 2: Grays Harbor Navigation Channel Reaches

1.2 Federal Project and Study Authority

This limited reevaluation was initiated at the request of the Port of Grays Harbor (Port) to investigate deepening the Grays Harbor navigation channel, which was not constructed to the authorized depth, based on post-authorization evaluation described below. Congress authorized the NIP in the Water Resources Development Act (WRDA) of 1986, Public Law 99-662. The authorizing legislation is as follows:

PUBLIC LAW 99-662 – NOV 17, 1986

> Section 202 General Cargo and Shallow Harbor Projects
>
> AUTHORIZATION FOR CONSTRUCTION. – The following projects for harbors are authorized to be prosecuted by the Secretary substantially in accordance with the plans and subject to the conditions recommended in the respective reports designated in this subsection, except as otherwise provided in this subsection:
>
> GRAYS HARBOR, WASHINGTON
> The project for navigation, Grays Harbor, Washington: Report of the Chief of Engineers, dated May 4, 1985, at a total cost of $95,700,000, with an estimated first Federal cost of $63,100,000 and an estimated first non-Federal cost of $32,600,000.

The 1986 Navigation Improvement Project authorization provided for deepening the navigation channel to a project depth of -38 feet MLLW. The Corps evaluation presented in the 1989 General Design Memorandum (GDM), Grays Harbor, Washington, Navigation Improvement Project (NIP) resulted in a justified channel depth of -36 feet MLLW from the bar to Cow Point and -32 MLLW feet from Cow Point to Cosmopolis, based on detailed post-authorization engineering, environmental and economic studies[1]. The Corps deepened the channel in 1990, in accordance with the 1989 GDM. This is the current depth of annual maintenance dredging. The project was authorized for a total cost of $95 million, but total initial construction was less than $30 million.

Currently, the channel project depth is -36 feet MLLW up to Aberdeen (just past the Port terminals at Cow Point), and then -32 feet MLLW from there to the last deep-draft dock at Cosmopolis – a distance of about two miles. Based on the shoaling rate in the channel, an additional two feet of dredging occurs for advanced maintenance. Currently, the deep draft channel is dredged either annually or semi-annually depending on volume removed, which averages 1.9 million cubic yards[2] at an average annual cost of roughly $9,000,000[3] with a range of approximately $3-18 million since 1986.

[1] The economic analysis in the GDM was based on timber industry and log vessels that, at that time, did not need -38 ft MLLW
[2] This is based on Operations Dredging years from 2000 to 2012.
[3] The annual costs fluctuate and depend heavily on budget availability year to year.

1.3 Purpose and Scope of Limited Reevaluation

Historically, the Port of Grays Harbor, founded in 1911, relied upon renewable resources of the surrounding forest to conduct business. Two decades ago, shifting global demand from U.S. timber to less-costly sources from Russia and New Zealand put the Port of Grays Harbor's future in jeopardy (Millman 2011). This can be attributed in large part to the listing of the Northern spotted owl to the endangered species list in June 1990. The listing prevented the timber industry from clearing lands within a 1.3 mile radius of any spotted owl nest or activity site (Andre and Velasquez 1991). Harvest of timber in the Pacific Northwest was reduced by 80%, decreasing the supply of lumber and increasing prices (Brokaw 1996).

In 2007, to revive the port, Grays Harbor embarked on a redevelopment plan that included diversifying away from timber and focusing on developing new partnerships with manufacturers and exporters. The plan included capital investment of approximately $18 million in rail and rail capacity and an additional $200 million of private investment in port facilities. Due in large part to the Port's ambitious redevelopment plan and its touted "one day closer to Asia" than inland spots like Seattle and Tacoma, the Port has seen a steady increase in trade volume over the past decade. The Port of Grays Harbor's diversification of commodities has led to an increased cargo volume from 1.28 million short tons in 2006 to approximately 1.82 million short tons in 2012, representing a 42% increase, and is expected to continue to grow in the near future.

This Limited Reevaluation Report (LRR) documents the analyses undertaken within a limited scope, limited to the economics and environmental effects of deepening alternatives. The purpose of this economic analysis is to estimate the National Economic Development (NED) benefits associated with harbor improvements, specifically channel deepening, that are designed to allow more efficient navigation in Grays Harbor by the existing and future fleet.

At the request of the sponsor the economic evaluation is limited to the legislatively authorized depth of -38 MLLW and as such the recommended plan may or may not coincide with the plan that maximizes the NED benefits but the recommended plan is the plan that maximizes the NED benefits within the aforementioned constraints of limited depth.[4]

The economic analysis was prepared in level of detail commensurate with the complexity of the project. It is not intended for the analyses for Limited Reevaluation Reports (LRR) to be exhaustive, but should provide sufficient data to document the steps used in formulating and identifying the recommended plan.

[4] Generally in deep draft navigation economic analysis the economist would look at a host of depths and not limit the analysis to two depths.

1.4 Problems and Opportunities

The following sections summarize the known problems, opportunities, and objectives identified for the re-evaluation.

1.5 Problem

As a result of the current channel depth of -36 feet MLLW and the narrow tidal windows, deep draft vessels calling at Grays Harbor have to be partially loaded or experience tidal delays due to insufficient channel depth. Figure 3 below shows all the vessels, design versus departure draft depth, which entered the Port of Grays Harbor during 2012. The blue indicates the design draft of each vessel and the pink indicates the greatest draft utilized during the vessel call, either inbound or outbound. From the figure you can see that as the vessel design draft gets larger so too does the amount of blue showing. This blue indicates that vessels are partially loaded (constrained) during their arrival or departure depending on whether the vessel is exporting or importing, and as the vessels get larger so too does the discrepancy between the design drafts and the transit drafts.

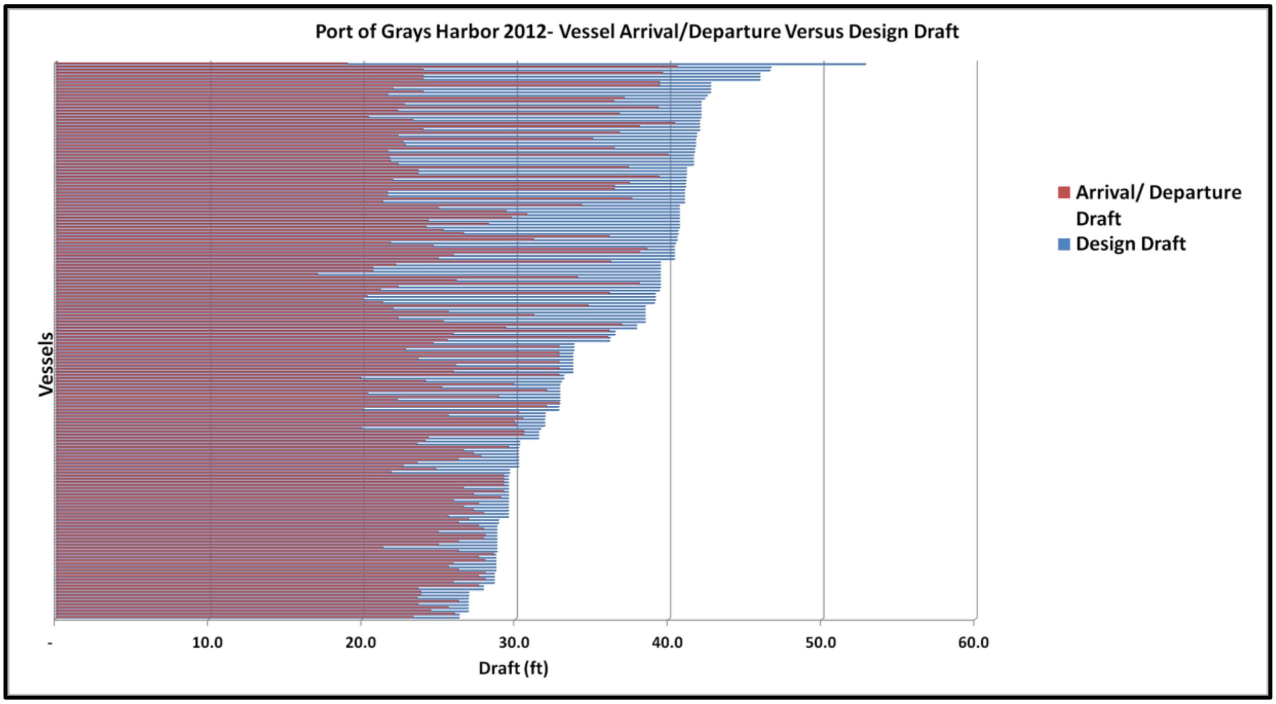


Figure 3: Vessel Departure Draft versus Vessel Design Draft

In 2012, the Port of Grays Harbor had approximately 44 vessels calling on the Port with vessel design drafts that are equal to or exceed -36 feet (current channel depth). By taking into account Figure 3 above and Figure 4 below one can see the potential to gainefficiencies in operations by loading 44 or more[5] of the current vessels calling on the port more heavily.

[5] 44 vessels is a conservative number (i.e., one which understates the number of vessel calls restricted by channel depths) due to the fact that this simplistic observation did not account for the under keel

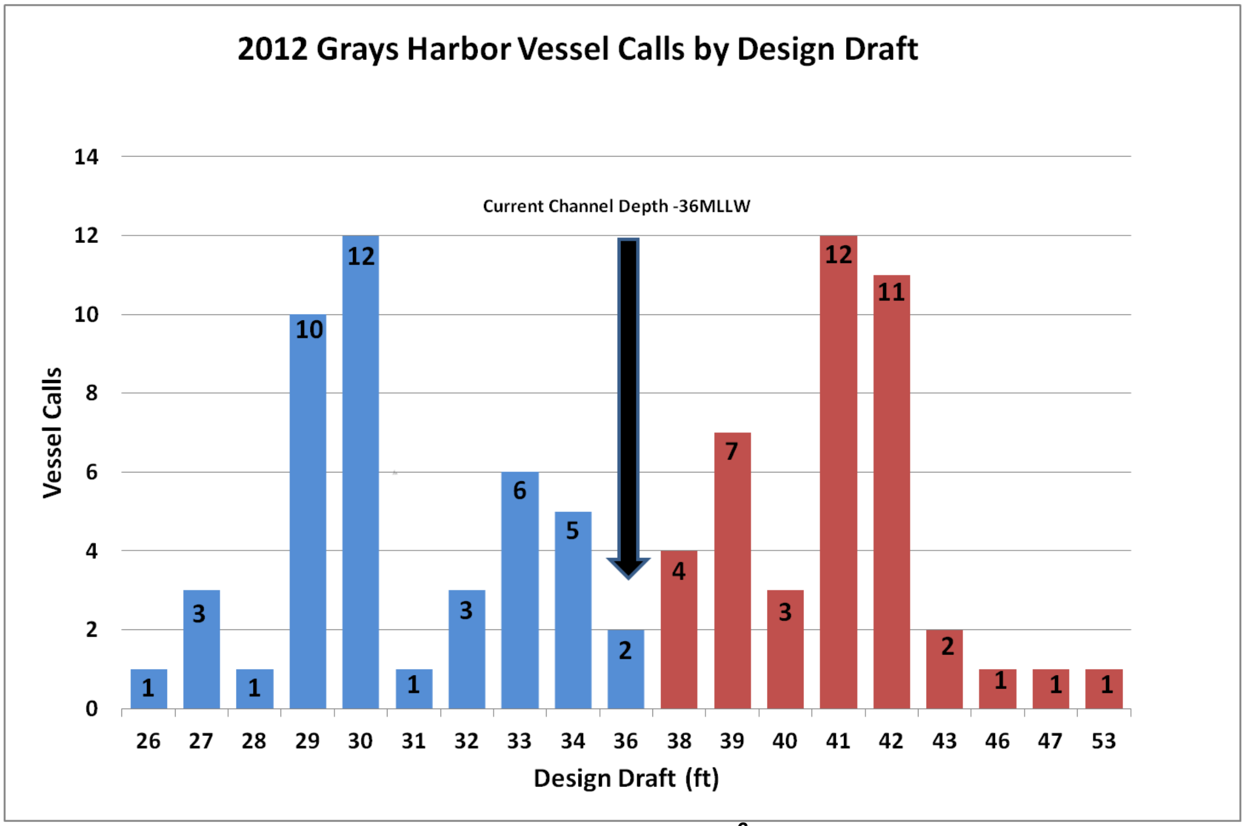


Figure 4: 2012 Port of Grays Harbor Vessel Calls[6] by Design Draft

1.6 Opportunities

Opportunities of a deeper navigation channel include:

- Vessels could operate more efficiently by being fully loaded or reducing tidal delays
- Increased efficiencies could result in decreased cost to move commodities through the Port of Grays Harbor
- Vessels carrying more cargo could reach the Port facilities
- U.S. producers could be provided improved access to world markets
- Economic competitiveness of producers would be improved
- Would allow increased beneficial use of dredged materials

1.7 Planning Objectives

The water and related land resource problems and opportunities identified in this study are structured as specific planning objectives to provide focus for the formulation of

clearance requirement of the vessels. Accounting for the under keel clearance would increase the number of vessels that may potentially gain from a deeper channel.

[6] The terms 'vessel transit' and 'vessel call' appear throughout the tables and the text of the entire report. For purposes of this report a transit can be interpreted as an individual arrival or departure, and a call can be interpreted as a cycle (arrival and departure).

alternatives. These planning objectives reflect the problems and opportunities and represent desired positive changes in the without project conditions.

The primary objective of federal navigation activities is to contribute to the Nation's economy while protecting the Nation's environmental resources in accordance with existing laws, regulation and executive orders. Navigation channels meet the federal objective by reducing transportation costs and improving the efficiency and safety of the deep-draft navigation system, thereby reducing vessel operating costs, resulting in potential savings to the consumer. The specific planning objective for this study is:

- Reduce navigation transportation costs for the existing and projected future traffic of deep-draft vessels, and improve efficiency and reliability of navigation to and from Grays Harbor over the 50-year period of analysis, as feasible and economically justified, within the parameters of the channel as legislatively authorized.

1.8 Planning Constraints

The following planning constraints represent restrictions that should not be violated. Compliance with environmental policies is addressed in the SEIS (Appendix C).

- The evaluation of alternatives to deepen the navigation channel beyond -36 ft MLLW will not re-evaluate the justification of deepening to -36 ft MLLW.
- The evaluation of alternatives to deepen the navigation channel will be limited to alternatives between -36 ft and the full legislatively authorized depth of -38 ft MLLW.

1.9 Planning Assumptions

The PDT developed the following preliminary assumptions. The PDT will review and refine these assumptions during the feasibility study:

- The segment of the channel being evaluated is dredged to its currently justified depth (i.e. -36 feet MLLW project depth plus two feet advance maintenance and two feet allowable overdepth) prior to implementing a recommended plan for a deepening project beyond a project depth of -36 feet MLLW.
- Annual maintenance dredging would occur within the same dredging year as a deepening project.
- Each of the deepening alternatives would require subsequent maintenance dredging.
- The minor channel alignment modification from South Reach to North Channel that Seattle District is pursuing separate from this reevaluation has been previously approved and implemented, resulting in significantly lower dredging volumes in the project area both for O&M and for construction of a deepening

alternative. (Dredging volumes assuming completion of this minor channel alignment modification were used in this reevaluation.)

- The reduction in vessel operating costs is cost savings that is passed on to the consumer, thus improving consumers' economic condition and quality of life.
- Approximately one to two percent of the material to be removed by new channel depth dredging (depending which action alternative is implemented) has been found to be unsuitable for open-water disposal. Therefore, a suitable upland disposal site will be required.
- Channel dimensions are not a present or expected limiting factor on cargo growth.
- The future without project vessel origin and destination are expected to be the same as the base year of 2017.

1.10 Alternative Plans

The scope of this feasibility study and thus this Economic Analysis is limited to evaluating the following three alternatives: No Action, deepening the channel to -37 feet MLLW, and deepening the channel to -38 feet MLLW. Note that each of the three alternatives also includes advance maintenance and allowable overdepth[7].

1.10.1 Alternative 1: No Action

Under the No Action Alternative, the Corps would continue channel maintenance as part of the NIP at the current dredging depth of -36 feet MLLW. Under Alternative 1, the Corps would continue the current practice of maintenance dredging of the navigation channel to a depth of −36 feet MLLW and placement of the dredged materials at a variety of open-water placement, nearshore nourishment, and beneficial use sites. A description of the existing Grays Harbor navigation channel maintenance involving the current dredging process and placement of dredged material is provided in Chapter 2 of the Supplemental Environmental Impact Statement (SEIS) in Appendix C of the LRR. It is important to note that the No Action Alternative does not achieve the objectives

[7] *Advanced Maintenance* is dredging to a specified depth and/or width beyond the authorized channel dimensions in critical and fast-shoaling areas and typically occurs during each annual dredge cycle. Advance maintenance would allow the Corps to avoid frequent re-dredging, and would ensure the reliability and least overall cost of maintaining channels to authorized and implemented dimensions (Corps 2006). To assure channel operational reliability and least overall cost, the Corps would allow an additional two feet to the navigation channel prism and three feet for the Elliot Slough Turning Basin. *Allowable overdepth* is dredging to a permitted depth and/or width outside the required channel prism to allow for inaccuracies in the dredging process. During typical dredging activities, inherent imprecision is known to occur that vary with physical conditions, dredged material characteristics, channel design, and type of dredging equipment used. Due to these variables, and the resulting imprecision associated with the dredging activity; the Corps recognizes that dredging below the congressionally authorized project dimensions would occur. To compensate for these inevitable inaccuracies, the Corps allows its dredging contractor to dredge with a maximum overdepth tolerance of two feet (Corps 1996).

described in 1.7, and is carried forward in this analysis for the sole purpose of comparative evaluation against the action alternatives.

1.10.2 Alternative 2: Deepening Channel to -37 MLLW

Alternative 2 would deepen the navigation channel by one foot, compared to baseline conditions (Alternative 1), to a depth of −37 feet MLLW. Construction dredging of Alternative 2 would occur over an approximate duration of six months for the inner harbor reaches, approximately 1.5 months longer than maintenance dredging under Alternative 1, and would occur within the same seven month dredge window as under Alternative 1. The duration of dredging for the outer harbor reaches would be approximately one month, the same as under Alternative 1. While the vast majority of the sediments from the inner harbor reaches (over 98%) are suitable for open-water placement, approximately 13,500 cubic yards of sediment that would be dredged during construction of Alternative 2 from the Cow Point 32a subunit are unsuitable for open-water disposal due to toxicity expressed in the sediment larval bioassay. This material would require appropriate upland disposal. Further explanation of channel sediment suitability is provided in the SEIS (Appendix C.)

1.10.3 Alternative 3: Deepening Channel to -38 MLLW

Alternative 3 would deepen the navigation channel by two feet, compared to baseline conditions (Alternative 1), to a depth of −38 feet MLLW. Construction dredging of Alternative 3 would occur over approximately six months for the inner harbor reaches (the same as Alternative 2), approximately 1.5 months longer than maintenance dredging under baseline conditions (Alternative 1), and would occur within the same seven month dredge window as under Alternative 1. The duration of dredging for the outer harbor reaches would be approximately 1 month, the same as under Alternatives 1 and 2. Approximately 22,400 cubic yards of sediment that would be dredged during construction of Alternative 3 from the Cow Point 32a subunit are unsuitable for open-water disposal due to toxicity expressed in the sediment larval bioassay. This material would require appropriate upland disposal. Further explanation of channel sediment suitability is provided in the SEIS (Appendix C.)

1.11 Economic Profile of Project Area

The major population surrounding the project location, assumed to be the majority user of the project area with respect to employment and tax income from operations, is the population of Grays Harbor County, Washington. As such, most of the socioeconomic data is developed using demographic information for the residents of the Aberdeen, Grays Harbor County metropolitan area. The resident population of Grays Harbor County is approximately 73,000, with 57,000 of the resident population of age 18 and over (Bureau 2013). The total number of businesses in Grays Harbor County is approximately 1,747, with the highest percent of industries being in retail trade (15.8%), followed by accommodations and food services (13.2%), health care (12%), and construction (10.4%). Total employment in 2011 for Grays Harbor County was approximately 30,400 (BEA 2011). Per capita personal income from 2011 was approximately $35,000(WAESD 2013), with an estimated 2.5 persons per household

(Bureau 2013). The unemployment rate in December 2012 was approximately 12.4%, this approximately 3% higher than the average 9.36% unemployment rate for all counties in the state of Washington (BLS 2013).

1.12 Hinterland Transit Connection

Port of Grays Harbor is connected by numerous avenues of approach. The infrastructures associated with these connections are numerous highways, rail lines, and a regional airport.

1.12.1 Highway

Grays Harbor boasts a four-lane state highway connection (Highway 12) to Interstate 5. Unburdened by daily traffic jams, companies gain efficient and cost-effective highway access. The Port of Grays Harbor, in Aberdeen, is less than 1 hour from Interstate 5, via a four-lane state highway. In addition, I-5 connects to Interstate 90 that provides access to the Midwestern (a major supplier of food and farm product exports) and Central United States.

Figure 6: Washington State Highway Corridor (Port of Grays Harbor 2013)

1.12.2 Rail

Main line rail service to the industrial properties and marine terminals provides direct access to both Class 1 railroads Burlington Northern Santa Fe (BNSF) and Union Pacific (UP), via Rail America's Puget Sound and Pacific short line railroad (Figure 8: Main Line Rail). A rail loop runs through the marine terminal complex providing a continuous rail loop to all three main cargo terminals (Figure 7: Grays Harbor Local Rail). Utilizing this unique state-of-the-art rail infrastructure, unit trains can be continuously loaded or unloaded for movement through the Port's facilities.

Figure 7: Grays Harbor Local Rail Loop (Port of Grays Harbor 2013)

The construction of additional auto tracks, to increase the auto handling capacity at Terminal 4, was complete in 2011. A second rail loop at the harbor will be constructed, providing all shippers with additional import and export handling capacity. An inter-modal 2,800 lineal foot on-dock rail system with direct discharge options and four parallel spurs is available(Harbor, Marine Terminals 2013)

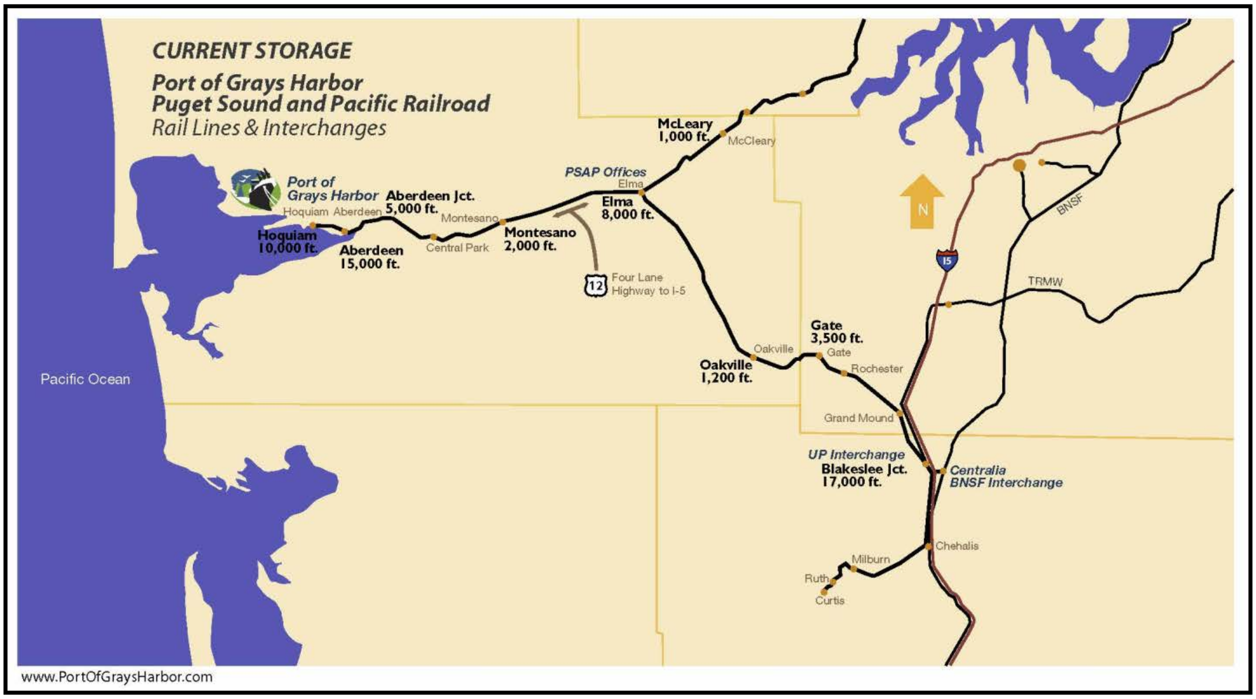


Figure 8: Main Line Rail Service (Port of Grays Harbor 2013)

The local rail system is serviced by a statewide mainline that then splits to connect Washington State to Canada and the midwestern United States (Figure 8: Main Line Rail). Much of the agricultural products that are being shipped through the Port of Grays Harbor is grown and shipped via rail from the midwestern U.S. and is serviced by the major railroad connections (Figure 9: Major Railroad).

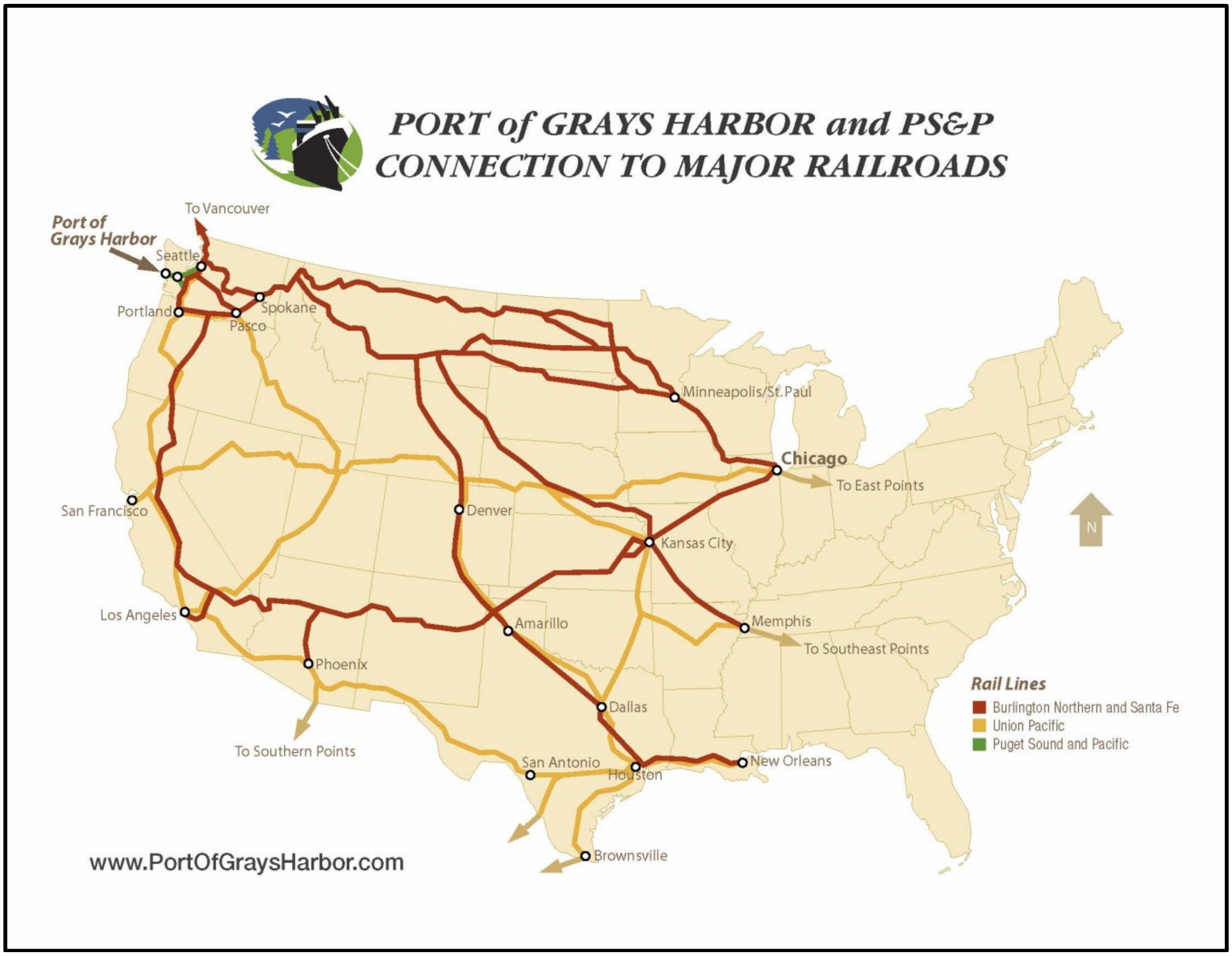


Figure 9: Major Railroad Connections (Port of Grays Harbor 2013)

1.13 Existing Shipping and Receiving Facilities

The Port of Grays Harbor currently offers four marine terminals. The terminals are supported by large, paved, secured cargo yards, the Port's on-dock rail system, and more than 104,000 square feet of on-dock covered storage. In addition, the Port has a rail loop and ladder track system that goes through the entire facility with a rail yard capable of storing 450 rail cars on the marine terminal. The port is positioned centrally between the Pacific Northwest markets of Seattle, Washington and Portland, Oregon. Grays Harbor is connected to its hinterlands by rail and the only four lane coastal highway North of San Francisco (Highway 12)[8].

Terminal 1 was converted in 2009 from a wood chip barge loading facility to a liquid bulk terminal capable of handling Panamax class vessels. It provides liquid bulk commodity shipping access to Port customers Imperium Grays Harbor and Westway Terminal Company. Terminal 2 is a state–of-the-art dry and liquid bulk facility that is served by a

[8] "The inland trade region served by a port is called its hinterland. That hinterland usually consists of a number of cargo hinterlands defined by the inland origins or destinations of specific commodities. Collectively, the cargo hinterlands of actual and potential commerce of the project port define the economic study area."(IWR 2010)

rail loop. Terminal 3 is a 150 acre marine industrial site with a deep water terminal and on-site rail. Terminal 4 is the largest terminal with approximately 1,400 ft long berth capable of handling two vessels. Terminal 4 is also served by the loop track and is equipped with dockside warehousing, paved uplands and on-dock rail service. It serves as the primary roll on roll off (RO/RO) and break-bulk cargo terminal. Table 1 below summarizes and provides additional information on each terminal.

Table 1: Summary of Existing Shipping and Receiving Facilities at Port of Grays Harbor

Terminal	Length (feet)	Depth (feet)	Use(s)
Terminal 1	480	-41 MLLW	Barge & Bulk Liquid
Terminal 2 Liquid Bulk	600	-41 MLLW	Liquid Bulk
Terminal 2 AGP	600	-41 MLLW	Agricultural Processing
Terminal 3	600	-41 MLLW	
Terminal 4	1,400	-41 MLLW	Auto and Ro/Ro[9]
Weyerhaeuser	**1,250**	**N/A**	**N/A**

1.13.1 Terminal 1

[10]Terminal 1 operates as a tanker, barge, and bulk liquid loading facility with adjacent uplands storage area. It provides liquid bulk commodity shipping access to port customers Imperium Grays Harbor and Westway Terminal Company. Berthing depth is -41 feet MLLW, 480 feet long, 50 feet wide, and served by an on-site rail loop (Harbor, Marine Terminals 2013).

Figure 10: Terminal 1

Imperium Renewables is submitting a permit application in 2013 for the construction of new storage tanks, rail infrastructure and office space. These permits will provide Imperium the opportunity to develop an additional 10.7 acres that are within the Port of Grays Harbor and are adjacent to the existing Imperium biodiesel plant. Imperium anticipates that the products stored on site will vary over the life of the facility, and may include biodiesel, ethanol, U.S. crude oil, jet fuel, gasoline, diesel, vegetable oil, and feed stock (Renewables 2013). Imperium intends to proceed with its present permit applications, and intends to implement these upgrades to facility and infrastructure regardless of whether the proposed deepening of the existing channel is accomplished. Thus, this development would be reflected in both the -with and -without project conditions.

[9] Roll-On/Roll-Off Vehicle Based Shipping
[10] Photos for Figure 8-11 taken from http://www.portofgraysharbor.com/terminals/terminals.php

1.13.2 Terminal 2


Figure 11: Terminal 2

Terminal 2 operates as a bulk loading facility. Terminal 2 is not specifically designated to any bulk commodity but is leased to AGP and they are consistently moving the same products (soybean, and soybean mill) from that terminal. Berthing depth is -41 feet MLLW, 600 feet long and 100 feet wide. It includes 75 paved acres, secured cargo yard and near dock warehousing. The facility also includes enclosed conveyers that transport product from the receiving building through a sampler and inline scales into the vessel. The Port, in conjunction with Ag Processing Inc, a grower-owned cooperative in the Midwest, developed the state-of-the-art terminal (Harbor, Marine Terminals 2013). In 2011, AGP added another dump house, storage silos, shipping bins, and conveying system that connect to the existing ship loader.

1.13.3 Terminal 3


Figure 12: Terminal 3

Terminal 3 is a 150+ acre site with a deep water marine terminal. The Port has installed on-site rail access which is served by the Burlington Northern & Santa Fe (BNSF) and Union Pacific (UP) railroads. It is less than a mile from Bowerman Airport and linked to Interstate 5 by a four-lane state highway. The 600 foot long, 120 foot wide berthing depth is -41 feet MLLW (Harbor, Marine Terminals 2013).

Grays Harbor Rail Terminal, LLC is proposing bulk liquids rail logistics facility at Terminal 3 to handle liquid bulk, primarily crude oil or light oil. Grays Harbor Rail Terminal, LLC conducted a feasibility study in 2013 to explore the option to bring a bulk liquids rail logistics facility to the Port of Grays Harbor. As a result of the findings in the feasibility study, the Port Commission granted Option to Lease T3 property to Grays Harbor Rail Terminal for twenty-four months to allow for further analysis and obtaining of permits to bring the project to shovel-ready.

1.13.4 Terminal 4

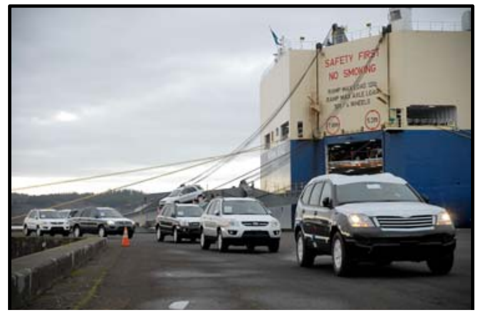


Figure 13: Terminal 4

Terminal 4 is the Port's main general cargo terminal. It features over 100,000 square feet of dry, covered warehouse space; a rail loop with on-dock rail access to BNSF and UP railroads, linked to Interstate 5 by a four-lane state highway, 120 acres of paved cargo yard, and twin self-scouring deep-water berths 1,400 feet long, 100 feet wide with water depth at -41 feet (-12.5 meters) MLLW(Harbor, Marine Terminals 2013). The Port of Grays Harbor provides shippers with more than 100 acres of secured outdoor storage adjacent to two deep-water marine berths. The port is emerging as a leading auto export center in the Pacific Northwest. Pasha Automotive Services, the lessee of Terminal 4, signed a 20 year agreement with the Port of Grays Harbor in in 2009 and as of August 2012 moved over 100,000 Chrysler vehicles through the port (Bruscas 2012).

1.13.5 Weyerhauser Independent Terminal

Although not a major user today or in the near future of the Grays Harbor Navigation Channel, it would be remiss to not mention Weyerhaeuser. There are a few independent terminals for handling log vessels and wood products that are operated by Weyerhaeuser. The log terminal is 1,075 feet in length and the wood products terminal is 1,250 feet in length. Currently this facility is moving little to no major volumes of commodities, and, as such, is not being factored into the economic analysis. The small volume being moved through the independent terminal is not expected to affect the tentatively selected plan for this study. In addition, the locations of these facilities are upriver of the proposed Navigation Improvement Project (NIP) improvements and would not be a major benefactor of said improvements.

2 Multiport Analysis

In 1982, Assistant Secretary of the Army for Civil Works ASA(CW) William Gianelli asked the U.S. Army Corps of Engineers to develop procedures for analyzing deep draft ports, which included data and analysis of competing ports. The basic problem was defined to be the need for a methodology to identify the traffic which could swing from or to the port under study with modest shifts in relative costs (between ports). A multiport analysis approach was developed by the Corps of Engineers and used to evaluate potential benefits due to savings on the land leg and port cost differentials. Combined land leg, port and ocean leg costs were then obtained for the port under study and its competing ports. Finally, the conditions under which some part of the traffic would logically be diverted from one port to another were discerned.

The Economist's role in multiport analysis is to identify relevant competing port trade flows based on analysis of trade routes, commodities, and port facilities. Commodity movements to or from competitive inland hinterlands to or from the same world trade areas are candidates for detailed analysis. Where the commodities are not identical (such as wheat and corn), or the trade routes are distinct (such as exports to different world areas), the opportunities for commodity transfers, based on port deepening alone, are likely to be low as is the case for the Port of Grays Harbor.

Multiport analyses may or may not be needed depending on circumstances. Specifically the Port of Grays Harbor's most likely competing ports are Tacoma, Portland, Kalama, Longview, and Seattle. For Tacoma and Seattle the leading export/import is containerized cargo, whereas at Grays Harbor the leading import/export is break-bulk, liquid bulk, and vehicles. In addition, the Port of Grays Harbor is predominantly export-based, whereas the overwhelming majority of trade at the Port of Tacoma and the Port of Seattle are imports. The Ports of Longview, Kalama, and Portland are at a minimum an additional 66 miles inland from the Pacific Ocean and require, at a minimum, an extra 16 hours for a vessel transit. The additional time moving through the Columbia River channel requires that a Harbor Pilot, that is generally costly, guide the vessel during the longer voyage through the channel. This is not the case with respect to the Port of Grays Harbor.

It is also believed that the additional 2 feet of depth proposed for the Port of Grays Harbor is not sufficient enough of a depth to warrant a change in commodity routes from the aforementioned Ports to Grays Harbor. One reason this is believed to be the case is the competing Ports have a depth that already exceeds what is requested in the Port of Grays Harbor. That is to say that the existing shipping companies are not expected to gain any advantages or enough of a cost savings, due to depth, by shifting goods moved through the competing Ports to the Port of Grays Harbor because they already have depths that exceed -38 MLLW.

In addition, and probably the most convincing argument for not needing a multiport analysis, Grays Harbor's hinterland and commodities are not identical to any of the aforementioned Ports. That is to say that Kalama, Longview, and Portland generally service agriculture grown within the Columbia River Valley, whereas the Port of Grays Harbor services agricultural products from the Midwest (Iowa, Minnesota, Missouri and Nebraska). In order for the Port of Grays Harbor to take advantage of goods produced in the Columbia River Valley they would need to be loaded on trains that would move past perfectly acceptable ports such as Kalama, Longview, and Portland. This is attributed to the setup of the existing infrastructure and rail corridor in the vicinity of the Columbia River Valley. For this transition to occur the cost per ton to move bulk items would have to be significantly cheaper at the Port of Grays Harbor than at said ports. This is highly unlikely due to the fact that Kalama, Longview, and Portland have channel depths that exceed the Port of Grays Harbor and are capable of being more efficient with respect to large bulkers.

Also of concern is the potential for other Ports to obtain business from the Port of Grays Harbor. This was analyzed and determined unfounded due to the fact that Grays Harbor is the basic business model of the Port of Grays Harbor is one of partnership. AGP, one of the major movers of agricultural products, owns the terminal where most of the agricultural tonnage is exported. This seven-state cooperative has invested millions of dollars in capital into the Port of Grays Harbor. It is unlikely that AGP would walk away from the partnership with the Port of Grays Harbor when so much capital is at stake. The business partnership model is also adhered to at the other Ports mentioned and this same argument could be applied to them from the other perspective of business being lost from them to the Port of Grays Harbor.

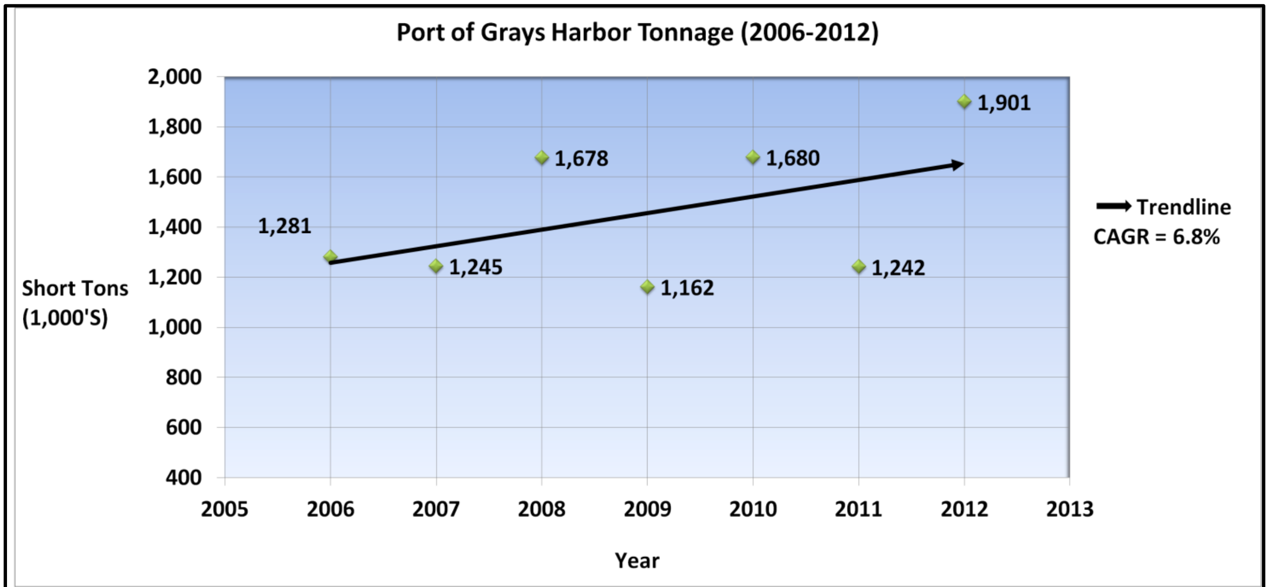
These circumstances surrounding the Port of Grays Harbor lead us to believe that commodity transfers or change of mode between competing ports is not expected to happen. Thus any movement of goods and services from competing ports is expected to be minimal at best and as such a multiport analysis is assumed unwarranted for this project.

3 Existing Conditions

3.1 Tonnage[11]

After the initial steep decline in tonnage in the late 1990s, mostly attributed to the listing of the Northern spotted owl as an endangered species, the Port of Grays Harbor has seen a general increase of tonnage movement (Figure 14: Port of Grays Harbor Historic Tonnage). The revival of the Port, based on a redevelopment plan, is due in large part to the Port's strategy change. This change was to focus on providing goods and services over a broad range of commodities, essentially an exercise in diversification. Grays Harbor has transformed their marine terminal operations from a heavy dependence on forest products to a diverse cargo mix employing hundreds in this rural community. Working closely with private partners, Grays Harbor has attracted over $200 million in private investment in the marine complex and infrastructure improvements, resulting in steady shipping calls and increased cargo shipments by truck and rail(Harbor, Port of Grays Harbor Info 2014). Figure 13 shows that in 2006 the Port of Grays Harbor moved approximately 1.28 million short tons and by 2012 was moving approximately 1.9 million. This represents a compound annual growth rate (CAGR) of approximately 6.8%. The variance or fluctuations seen in the Port tonnage year over year can be attributed to a multitude of factors. The drop in tonnage in 2009 is directly related to the 2008 financial crisis where world demand of goods and services dropped. In addition, other year's fluctuations in the tonnage moved through the Port of Grays Harbor are due to a host of environmental factors such as commodity (soybean prices), exchange rate fluctuations, and inventory availability.

[11] All 2012 tonnage data was provided by the Port of Grays Harbor Pilot Logs as the Waterborne Commerce Statistics Data Center information was not available at the time of this analysis.



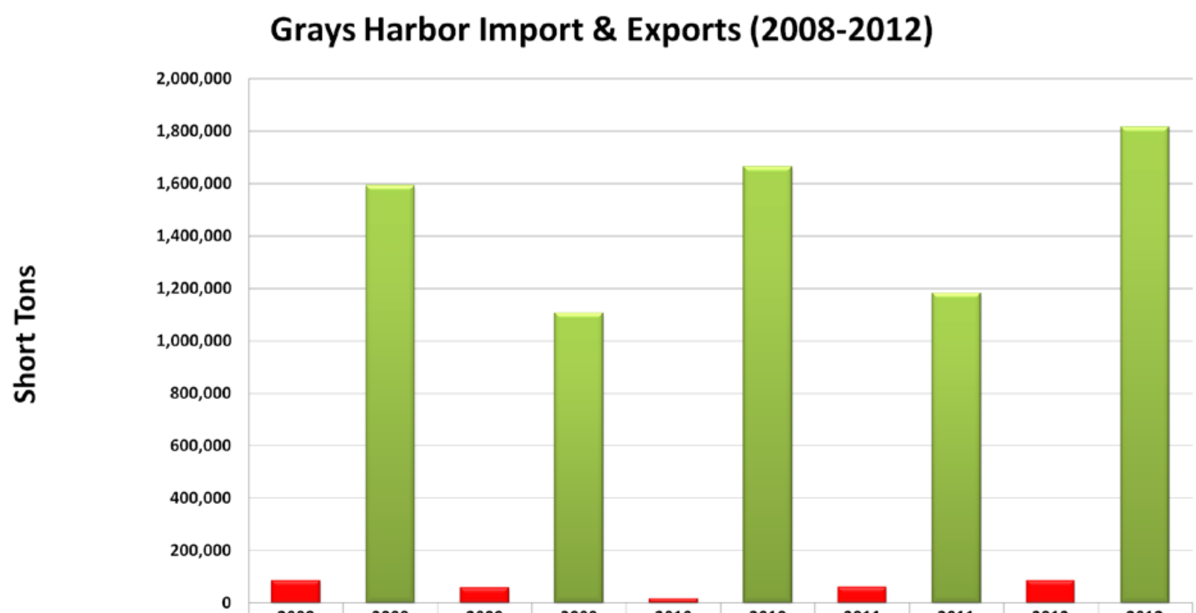
[12]

Figure 14: Port of Grays Harbor Historic Tonnage

As of 2012, the latest hard data available, approximately 1.9[13] million short tons was moved through Grays Harbor. Of the 1.9 million tons moved, approximately 96% (Figure 15: Historic Import and Export Tonnage by Year) is export based going to places such as China and the Philippines.

[12] Data displayed has a standard deviation of approximately 290k and displays an above average CAGR. The trend displayed is not expected to continue at the current CAGR of 6.8% but is expected be somewhere around 1-2% depending on the commodity.

[13] Note that the same type of summary values in the tables presented herein may not exactly match each other due to the rounding of values and/ or to values obtained from different sources. These differences are insignificant and as such do not affect the analysis.



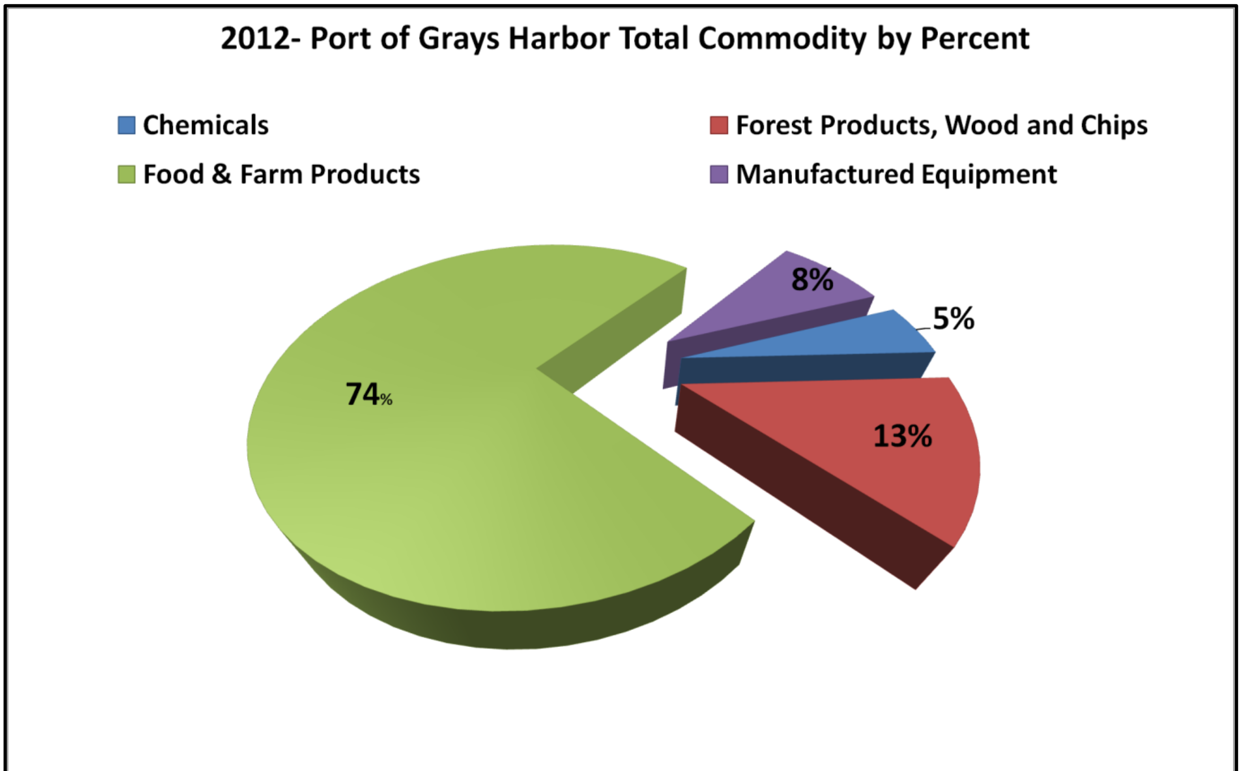
	2008 Imports	2008 Exports	2009 Imports	2009 Exports	2010 Imports	2010 Exports	2011 Imports	2011 Exports	2012 Imports	2012 Exports
Total Commodities	85,543	1,592,661	56,749	1,105,692	16,536	1,663,454	59,556	1,182,024	85,628	1,815,081

Figure 15: Historic Import and Export Tonnage by Year

3.2 Historic and Existing Commodity Movements

Historically, the Port relied heavily on forest products such as lumber and wood chips to support business activities. The aforementioned strategic change has led to the Port's new main line of businesses, based on pure tonnage moved, of food and farm products, followed by forest products. The category Food and Farm Products includes things such as soybean, soybean meal, distilled dried grains, and corn (Figure 16: Existing Commodity Breakdown).

Although, the Port of Grays Harbor has decreased its reliance on one commodity, such as lumber, a heavy reliance on agriculture remains. An overwhelming majority of the tonnage moved during 2012 was agriculture related goods (74%). Through inordinate concentration on one commodity category, the Port of Grays Harbor, although unlikely, may again find itself in a similar situation as was the case with the timber industry in the 90's. Evidence to the contrary is the long standing relationship between the Port of Grays Harbor and Ag Processing Inc (AGP), the largest shipper at the Port of Grays Harbor, dating back to early 2003, and the multimillion-dollar expansion project at the Port that AGP undertake in 2010. The additional capital invested in the infrastructure indicates a long term perspective on the part of the tenants. In addition, despite the global recession of 2009, the Port of Grays Harbor continued to move agricultural products indicating a relative inelastic demand for agriculture.



[14]

Figure 16: Existing Commodity Breakdown

Table 2 shows the total annual commodity tonnages at the Port for the period 2006 through 2012, and the associated annual growth rate for each year. The compound annual growth rate (CAGR) for the aforementioned periods is approximately 6.8%. This can mostly be attributed to strong demand for soybean and other agricultural products from China and the Philippines. The fluctuations seen in the Port tonnage year over year can be attributed to a multitude of factors. The drop in tonnage in 2009 is directly related to the 2008 financial crisis were world demand of goods and services dropped. Other annual fluctuations in the tonnage moved through the Port of Grays Harbor are due to a host of environmental factors such as commodity (soybean prices), exchange rate fluctuations, a particularly productive harvest (bumper crop), or lack thereof, and abundant foreign supply of similar agricultural products.

[14] The 74% Food and Farm Products in the figure above are things such as soybean, corn, oil see, and animal feed. These were not further broken out due to the fact that these commodities use similar modes of transportation such as vessels, routes, and rail car. Thus, any benefits associated with Food and Farm Products would apply across all the aforementioned commodities.

Table 2: Grays Harbor Total Annual Cargo

Grays Harbor Total Annual Cargo Short Tons		
Year	Total Tons	Annual Growth Rate (year-to-year)
2006	1,280,578	
2007	1,244,705	-2.8%
2008	1,675,699	34.6%
2009	1,162,441	-30.6%
2010	1,679,991	44.5%
2011	1,241,580	-26.1%
2012	1,900,708	53.1%
Compound Annual Growth Rate (2005-2012)		6.8%

Table 3 summarizes the historic commodities moved through the Port of Grays Harbor and gives a general overview of the amount of each major commodity moved from 2008 through 2012. The table shows a significant increase in both manufactured equipment (vehicles) and food and farm products (soybean) that are moving through the Port.

Table 3: Short Ton by Commodity[15]

Port of Grays Harbor Historic Short Ton by Commodity					
	2008	2009	2010	2011	2012
Chemicals	90,650	66,793	14,964	131,084	94,082
Forest Products, Wood and Chips	988,223	331,205	530,807	347,887	251,814
Food & Farm Products	595,672	756,825	1,094,985	677,797	1,396,313
Manufactured Equipment	1,154	7,618	32,413	84,811	158,499
Total Commodities	1,678,204	1,162,441	1,679,991	1,241,580	1,900,708

The preliminary 2013 cargo volume and vessels call data are approximately 2.65 million short tons with 102 vessel calls.

From a pure dollar perspective, the Port's most valuable export is Manufactured Equipment. This category consists mostly of Jeep, Chrysler, and Dodge vehicles shipped via roll-on roll-off vessels. The change from forest based products to more valuable market commodities, such as vehicles, has led to a drastic increase in the value of commodities moving through the Port. There has been an increase from approximately $255 million in 2008 to nearly $2 Billion in 2012 (Resources, Institute for Water 2013) representing a 665% increase in the value of the goods being shipped.

[15] Table 3 left out unknown commodities, primary manufactures and oil as they are historically not a substantial volume moved.

3.3 Origins and Destinations

The majority of cargo shipped through the Port of Grays Harbor in 2012, principally exports, headed to southeast Asian countries with the Philippines', at approximately 59% of total commodities moved, being the prevailing trade partner (Figure 18: Commodity Origin and Destination.) The Philippines is the furthest trade partner away from the Port of Grays Harbor at almost 6,000 nautical miles. The Port of Manila with a cargo pier depth of 40 feet (12.2 meters)(Ports.com 2014) is the country's primary international gateway for shipping and is located on the shores of Manila Bay.

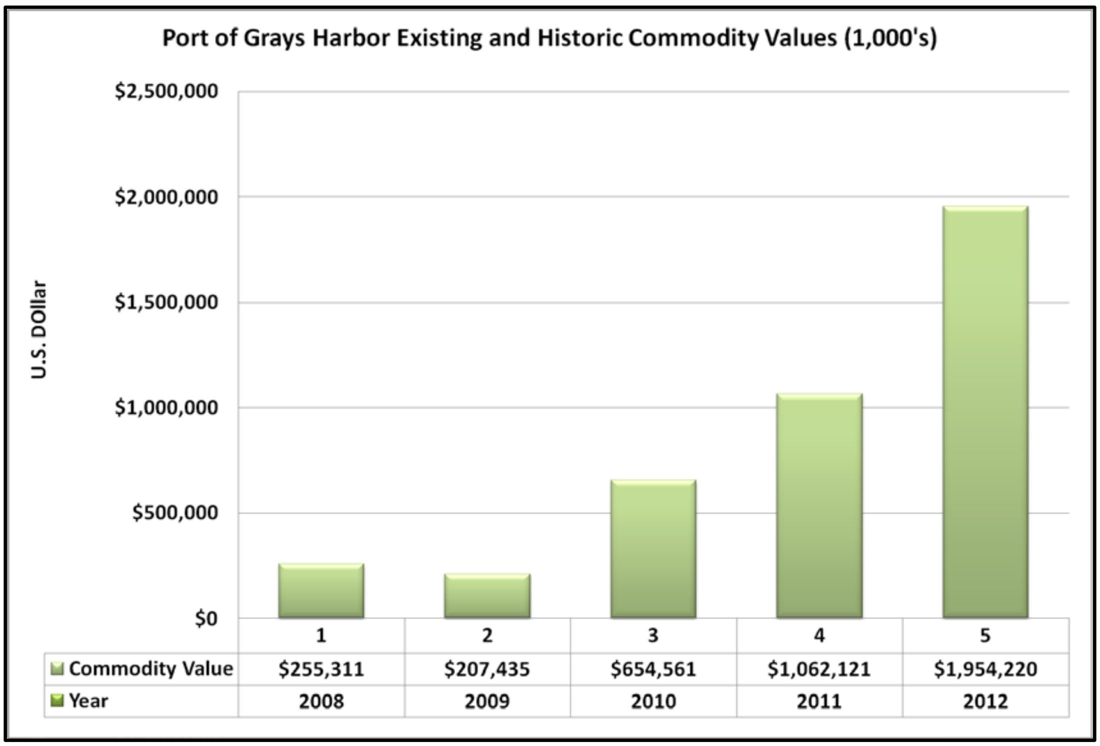


Figure 17: Historic Commodity Values

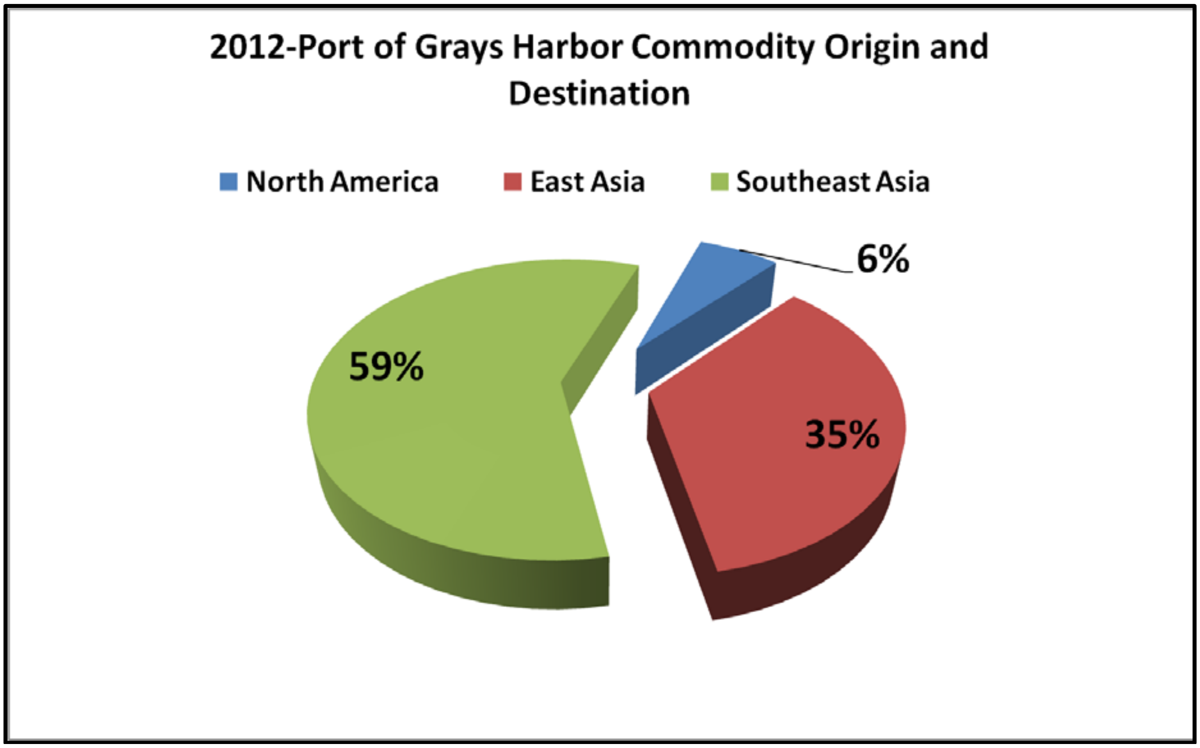


Figure 18: Commodity Origin and Destination

China is the second largest trade partner at approximately 21% of total trade volume by short ton. Agricultural and manufactured equipment (Chrysler, Dodge, Jeep vehicles) is the predominant commodity with respect to the trade relationship between Grays Harbor and China. The goods move through the Port of Shanghai, a deep draft port (-52 ft) on the confluence of the Yangtze River, Huangpu, and Qiantang Rivers.

Each major trade partner was aggregated into 1 of 3 specific route groups for the simplicity of analysis[16]. The Ports of Call were aggregated based on locations and distances with respect to one another. For example; the East Asia trade group includes countries such as China and Vietnam as they are relatively close to each other and the distance from the Port of Grays Harbor are similar (Table 4: Grays Harbor Port of Call Characteristics). To assign Sea Distance in Harborsym (a Monte Carlo simulation model for deep draft navigation economics) to the route groups the following strategy was applied. The minimum distance traveled to each assigned destination was assigned as the minimum Sea Distance, the maximum distance traveled to each assigned destination was assigned as the maximum Sea Distance in Harborsym, and the average distance of the destinations in each route group was used as the most likely Sea Distance in Harborsym.

[16] Origin and destination ports of the goods moving through the Port of Grays Harbor were reviewed and found to be more than adequate, with respect to depth and infrastructure, to handle the vessels moving from and to the Port of Grays Harbor.

Table 4: Grays Harbor Port of Call Characteristics

Grays Harbor Port of Calls				
North America				
Port Name	**Average Nautical Miles**	**Route Group**	**2012 Short Tons**	**% of Sub-total**
United States	443	RtGrp1	70,559	4%
Vancouver Canada	238	RtGrp1	47,238	2%
Lazaro Cardenas, Mex	2,129	RtGrp1	4,423	0%
East Asia				
Port Name	**Average Nautical Miles**	**Route Group**	**2012 Short Tons**	**% of Sub-total**
S. Korea	4,573	RtGrp2	70,066	4%
China	5,030	RtGrp2	392,720	21%
Japan	3,976	RtGrp2	83,425	4%
Vietnam	6,542	RtGrp2	42,825	2%
Russia	4,208	RtGrp2	79,169	4%
Southeast Asia				
Port Name	**Average Nautical Miles**	**Route Group**	**2012 Short Tons**	**% of Sub-total**
Phillipines	5,889	RtGrp3	1,037,923	54%
Indonesia	7,353	RtGrp3	35,666	2%
New Castle, AU	6,617	RtGrp3	44,847	2%
TOTAL			**1,908,861**	**100%** [17]

3.4 Existing Vessel Fleet

Vessels calling the Port of Grays Harbor were broken down into four main categories; Articulated Tug Barge (ATB's), Tanker, Bulker, and Roll On Roll Off (Ro-Ro) because these four vessel types account for most - if not all - of the vessel types calling at the Port that would potentially benefit from the proposed channel deepening project. All vessels traversing the Port of Grays Harbor are potentially adversely affected by the existing restrictive channel depths due to the fact that there are congestion externalities that exist. For example, if a larger vessel has priority over a smaller vessel then the smaller vessel will still have to wait for the larger vessel to enter and clear the channel. So even though a shallower draft vessel may be well within the depths needed to traverse the channel it could still remain on standby due to the wait imposed on the larger ship that does have a depth constraint. These four categories were further broken down in the HarborSym program to account for the different sizes of each vessel type. For example, Tankers were broken down into Small Tanker, Medium Tanker, and Large Tanker. The specific class and sizes are found in the table Vessel Descriptions and Capacity below.

[17] The distances from and to the Port of Grays Harbor from and to the port of call was determined through the use of seadistances.com (SEA DISTANCE - VOYAGE CALCULATOR 2013).

Figure 19: Vessel Description and Capacity

Vessel Description and Capacity	
Vessel Description	**Dead Weight Tons**
ATB 30k	15,001-25,000
Bulker 10k	1,500-15,000
Bulker 20k	15,001-25,000
Bulker 30k	25,001-35,000
Bulker 40k	25,001-45,000
Bulker 50k	45,001-55,000
Bulker 60k	55,001-65,000
Bulker 70k	65,001-75,000
Bulker 80k	75,001-105,000
Ro-Ro 10k	1,500-15,000
Ro-Ro20k	15,001-50,000
Tanker-Small	4,000-50,000
Tanker-Medium	30,000-70,000
Tanker-Large	60,000-80,000

This allows the simulation program the ability to sort the different Tanker vessels calling the ports into different sizes. The types of vessels and the major route group associated with each vessel type are broken down by percentage in Table 5 below.

Table 5: Vessel Class by Route Group

Vessel Class Route Group			
Class Name	**North America**	**East Asia**	**Southeast**
Tanker	**0%**	**4.0%**	**2.3%**
Bulke	**95.9%**	**73.0%**	**97.7%**
Ro-Ro	**4.10%**	**22.0%**	**0%**

3.4.1 Tankers

In 2014, tankers currently do not play a major role in commodity movements within the Port. However, this is expected to change in the near (1-year) to intermediate (5-year) future (see 4.2) and, as such, will form part of the without-project condition under this analysis. The future tanker fleet that will be calling the Port of Grays Harbor will be moving domestic crude and as such will be required to use domestic vessels in compliance with the Jones Act. The tanker fleet that will be calling the Port of Grays Harbor – possibly as early as the baseline year of 2017 and likely under the with-project condition – will be moving crude. These crude-carrying vessels are expected to be of different average characteristics than the small number of tankers historically calling at Grays Harbor, as displayed in Table 6. The draft of the future tanker vessels is expected to have a maximum design draft of -36 feet or less. The projected increase in the number of crude-carrying vessel calls at Grays Harbor is independent of project implementation. Discussions with the Port of Grays Harbor and the companies that are proposing to bring crude by rail projects to the Port have indicated that permit applications for infrastructure enhancements needed to facilitate the movement of crude by rail through the Port would be initiated regardless of an increase in the depth as proposed by the Corps. Conversations with future and existing tenants that are proposing to move crude have further indicated that the crude vessels expected to utilize the Port of Grays Harbor would be the same in the future with-project and future without-project conditions, consistent with the discussion of efficient use of vessel size classes in sections 23.2 and 24. The current deepening project would not make possible the entry of the tankers as they can enter under the existing conditions (-36 MLLW).

There is speculation that Canadian crude would utilize the Port of Grays Harbor thus the requirement to utilize Jones Act Fleet would not be in effect. Despite the provider of the crude the vessel sizes that will be utilized are expected to be the same due to fleet availability and preferences of the shipping companies.

The tankers used in 2012 visited from South Korea and the Philippines and accounted for 4%(Grays Harbor Pilot Logs 2013) of East Asia and 2.3% of Southeast Asia's Vessel Class Route Group (Table 5: Vessel Class by Route Group). The commodity associated with these movements is methanol, a liquid bulk item. The average vessel characteristics associated with tankers can be found below.

Table 6: Tanker Characteristics

Tanker Vessel Characteristics (Average)						
Net Short Tons	Gross Short Tons	DeadWt Short Tons	Length (ft)	Breadth (ft)	Depth (ft)	Design Draft (ft)
7,769	19,794	27,600	558	88	35	36

[18]

3.4.2 Bulker

Bulker vessels make up the largest portion of all traffic entering the Port by pure tonnage. The overwhelming majority of commodities loaded on bulk vessels are bound for the Philippines and China. The largest bulker has a design draft of approximately 47 feet and is used as a bulk agricultural vessel for exports to China. The average dimensions for bulker type vessels used in 2012 at the Port of Grays Harbor are found

[18] Gross ton includes the weight of the container (tare) and freight whereas net tons are just the weight of the freight.

in Table 7 below. In 2012 the Port experienced approximately 25 calls from bulker type vessels.

Table 7: Bulker Characteristics

Bulker Vessel Characteristics (Average)						
Net Short Tons	**Gross Short Tons**	**DeadWt Short Tons**	**Length (ft)**	**Breadth (ft)**	**Depth (ft)**	**Design Draft (ft)**
17,697	**32,549**	**53,328**	**624**	**101**	**34**	**39**

3.4.3 Roll On-Roll Off[19]

In 2012 the Port of Grays Harbor experienced approximately 20 Ro-Ro vessel callings. These vessels were used to move autos and other manufactured equipment. Most of the export vehicles were shipped to East Asian countries such as China, Japan and Russia. The average characteristics of the Ro-Ro can be found in the Table below.

Table 8: Ro-Ro Characteristics

Ro-Ro Vessel Characteristics (Average)						
Net Short Tons	**Gross Short Tons**	**DeadWt Short Tons**	**Length (ft)**	**Breadth (ft)**	**Draft (ft)**	**Design Draft (ft)**
14,463.64	**47,671.88**	**15,023.54**	**594.44**	**100.85**	**28.00**	**29.21**

Ro/Ro's are not necessarily directly adversely affected by existing channel depths due to the lower draft (~29 feet) but they are affected indirectly due to the aforementioned congestion externalities as well as the restricted tidal (time) window available to enter and exit the harbor.

[19] Roll-on/roll-off traffic refers to vessels that are designed to carry wheeled cargo that can be driven directly onto the vessel. Examples of the types of goods loaded on said vessels are automobiles and tractors.

4 Commodity Forecast

The planning horizon for this project is 50 years, with a base year of 2017[20] and a conclusion of 2067. A majority of the commodity forecasts for future conditions was taken from a Washington Public Ports Association (WPPA) and Washington State Department of Transportation (WSDOT) Marine Cargo Forecast (Associates, BST; IHS Global Insight; Mainline Management Inc. 2011). The remaining forecasts (petroleum) were taken from permit applications (Hoquiam 2013) and other public and private sources.

The purpose of the "Marine Cargo Forecast," is to assess the expected flow of waterborne cargo through Washington's port system and to evaluate the distribution of cargo through the state's transportation network, including waterways, rail lines, roads, and pipelines.

Since the mid 1980's the WPPA and WSDOT have jointly conducted periodic cargo forecast and performance assessments of the state's marine port transportation system for use in planning tools for the local port community. The review of these reports displays that they have been conservative to close to accurate across all commodity groups (Associates, BST; IHS Global Insight; Mainline Management Inc. 2011).

The forecasts were taken out and applied to the existing conditions (2012) through 2037, at which point the forecasts were held constant from 2037 through 2067. The reason the forecasts were held constant after 2037 is that forecasting tends to become less accurate when attempting to predict future conditions further out in time. The level of uncertainty increases as time elapses and it becomes more difficult to give an accurate estimate past 20 years into the future. In addition, the marine cargo forecasts display a moderate-growth and high-growth forecast growth percentage. The moderate-growth percentage was applied to the commodity growth rates for the Port of Grays Harbor to ensure that economically conservative projections were used throughout the analysis to reduce the possibility of overstating economic benefits.

The major categories used in the Marine Cargo Forecast (MCF) were broken down into Containers, Breakbulks, Neobulks, and Dry Bulks. These were further divided into subcategories such as Automobiles for Neobulk and Soybeans for Dry Bulk. The growth projections used and applied were taken from the specific commodity category that corresponds to the commodity being moved at the Port of Grays Harbor. According to the MCF, previous versions of the cargo forecasts have been conservative or close to accurate across all cargo types.

4.1 Caveats of Growth Estimates and Projections

The Marine Cargo Forecast used by WSDOT was developed based on unconstrained limitations in infrastructure. Although the forecasts are unconstrained the use of these forecasts were constrained in that the local infrastructure at the Port of Grays Harbor

[20] The base year 2017 is the first year that the project will be fully operational at the NED plan depth.

was taken into account when applying the increases in commodity tonnages and number of vessels that would be needed to move the increased tonnage over the 50 year period of analysis. The lower range of the Port's infrastructure capacity of 15.5 million short tons is not expected to impose a limitation on projected throughput with respect to tonnage.[21] However, the Port is expected to meet a limitation, based on the existing infrastructure, of the number of vessels the terminals can accommodate. This information can be found below in "Future Commodity Movements".

As with any forecast, growth forecasts have some associated uncertainty and are only used to help make an informed decision for planning purposes. The use of linear forecasts was applied but the true nature of economic markets is anything but linear. The general idea is that in the short run markets act erratic but in the long term the peaks and troughs are less sharp with respect to the extensive time horizon.

The WSDOT Cargo Forecast forecasts to 2030, whereas the forecasts used for the economic analysis took the forecast out to 2037, and then assumed commodity growth would level off because of the difficulty accurately forecasting farther out in time. This is a small extension of the forecast as the commodity growth percentages ranged from .2% to 3.9% and was done for the ease of analysis with respect to the HarborSym modeling suite. This additional extension in forecast years is not expected to change the outcome of the NED selected plan. The growth estimates are conservative and are relatively accurate based on the observation that the WSDOT Cargo Forecasts have generally been accurate predictions of future growth. In addition, growth is expected to adhere to the forecast in that, with implementation of a deepening project, growth is expected to follow the forecast[22] throughout the project life. There is no indication that new products, other than the petroleum products from the Midwest, or additional cargo beyond what has been analyzed to date is expected to present itself, based on the information drawn from regional reports, the niche markets (non containerized cargo) the Port of Grays Harbor is now operating in, and Port feedback,.

4.2 Future Commodity Movements

The Port of Grays Harbor principal trade partners are located in Asia and it is difficult to overstate the dependence and trade relationships that exist. China is especially critical to Grays Harbor and China's economy is expected to continue to grow and demand more goods, especially food and finished goods, from the United States. China's GDP growth rate as an annual percentage from 2008-2012 was approximately 7.8% (The World Bank 2013).

[21] The maximum capacity was found by looking at the Port infrastructure and direct input from the Port. The capacity had a range of 15.5 to 31.5 million short tons. The economic analysis is calling for a maximum of 11.7 million short tons. Thus the Port has ample capacity to handle the expected increase in tonnage over the 50 year period of analysis.

[22] A major concern at the Corps is to avoid basing a project's benefits on business that is not presently at the project location. The concern is to avoid improperly justifying a project on the supposition that if the channel is deepened, the business will come. The Port of Grays Harbor has enough current business to justify the project and additional business from outside the periphery of the project is not expected to present itself.

Along with China, the Philippines, a principal importer of agricultural and timber products from the Port of Grays Harbor, is expected to see GDP growth of approximately 6% this year, with a similar pace into 2014. This can be attributed to sustained growth in private consumption, a recovery in government spending, and positive net exports (Asian Development Bank 2013).

Another key piece to the growth of the volume of commodities moving through the Port of Grays Harbor is the expansive finds of shale oil in the U.S. Oil output from the U.S. and Canada is set to increase about 21% from this year to 2018, according to data from the International Energy Agency, largely a result of growing production from fracking and other technologies that access once-inaccessible reserves (Market Watch 2013).

The future commodity growth for the 50-year planning horizon from the base year of 2017 to 2067 is summarized in Table 9 and shown graphically in Figure 18 Port of Grays Harbor Commodity Growth Projections. Note that all commodity projections used the moderate growth forecast derived from the WSDOT Marine Cargo Forecast (Associates, BST; IHS Global Insight; Mainline Management Inc. 2011).

Table 9: Port of Grays Harbor Commodity Moderate Growth Projections (2017-2037)

Port of Grays Harbor Commodity Growth Projections (2017-2067)							
Commodity	**2017**	**2027**	**2037**	**2047**	**2057**	**2067**	**CAGR (2017-2037)**
Petroleum Moderate	8,467,922	8,638,812	8,813,152	8,813,152	8,813,152	8,813,152	0.2%
Chemicals Moderate	130,726	252,392	487,290	487,290	487,290	487,290	6.8%
Forest Products Moderate	267,290	301,153	339,307	339,307	339,307	339,307	1.2%
Food & Farm Products Moderate	1,445,873	1,550,332	1,662,339	1,662,339	1,662,339	1,662,339	0.7%
Manufactured Equipment Moderate	191,913	281,358	412,492	412,492	412,492	412,492	3.9%
Total Commodities Moderate	10,503,723	11,024,048	11,714,580	11,714,580	11,714,580	11,714,580	0.55%

[23]

Growth in cargo tonnage at the Port, for purposes of this 50-year analysis, is expected to be similar between the future with-project and future without-project conditions. This projected parity in cargo growth curves is primarily due to the extrinsic limitations on Port of Grays Harbor capacity that restrict the opportunity for cargo throughput. Given the existing facilities at the Port, predicted future growth under a future with- or without-project scenario will reach maximum capacity at an estimated 469 vessel calls/year based on the following calculation of an average vessel moving a set average tonnage:

- Terminal 1. Liquid bulks. Average days at berth = 3. 365/3 = 122 vessel calls
- Terminal 2. Agricultural dry bulk. Average days at berth = 5. 365/5 = 73 vessel calls
- Terminal 3. Breakbulk logs. Average days at berth = 6. 365/6 = 61
- Terminal 4A. Auto RORO. Average days at berth = 3. 365/3 = 122 vessel calls

[23] Much of the source of the petroleum projections were taken from direct contact with the entities proposing to move crude through Grays Harbor or from permits submitted the aforementioned entities and subsequent litigation of those requests.

- Terminal 4B. Breakbulk. Average days at berth = 4. 365/4 = 91 vessel calls

Vessel calls and, therefore, cargo capacity are limited by a number of terminal capacity factors including berthing space (number of berths at the Port), berthing depth (-42' MLLW), terminal space for cargo storage and re-handling, and intermodal capacity for delivery by rail of cargo for export, and are further limited by channel width under current channel maintenance conditions limiting concurrent two-way transit in the inner harbor. Per the Port's Executive Director, the Port does not currently have designs or funding in place to make major facility improvements that would facilitate expansion to support growth beyond that estimated maximum of 469 vessels per year. Similarly, the HarborSym modeling is showing vessel calls per year reaching a maximum at 491. The system starts deleting vessels in the later years at a higher rate possibly indicating a maximum threshold on par with the Port's estimated number of 469 vessels. This projected parity in growth expectations between with- and without-project conditions reflects an economically conservative perspective that reduces the likelihood of overstating the economic benefits of project implementation. Note that the SEIS takes a differing approach, and from an environmentally conservative point of view that NEPA document projects a greater increment of growth in cargo throughput under the future with-project condition than under the future without-project condition.

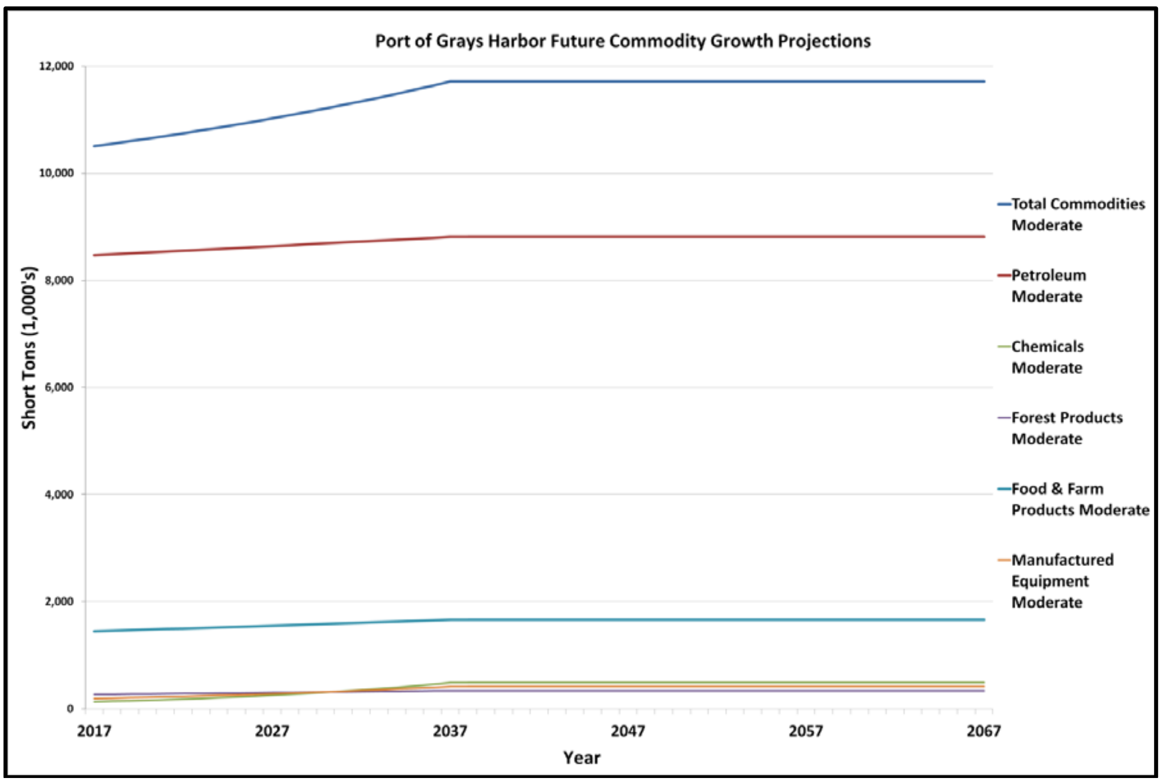


Figure 20: Port of Grays Harbor Commodity Moderate Growth Projections

4.2.1 Petroleum

Oil plays an important role in the U.S. economy, with petroleum accounting for approximately 37% of U.S. primary energy demand in 2010 (Energy Security Leadership Council 2012). America's energy boom has left the middle of the country awash in cheap oil for the first time in decades; the U.S. is experiencing a dramatic and sustained increase in domestic oil production. The key drivers of the oil boom are, in no particular order, high global oil prices, technology advances, and the demand for energy security. U.S. oil production is expected to reach approximately 6 million barrels per day (Figure 21: U.S. Production of Crude) by 2020.

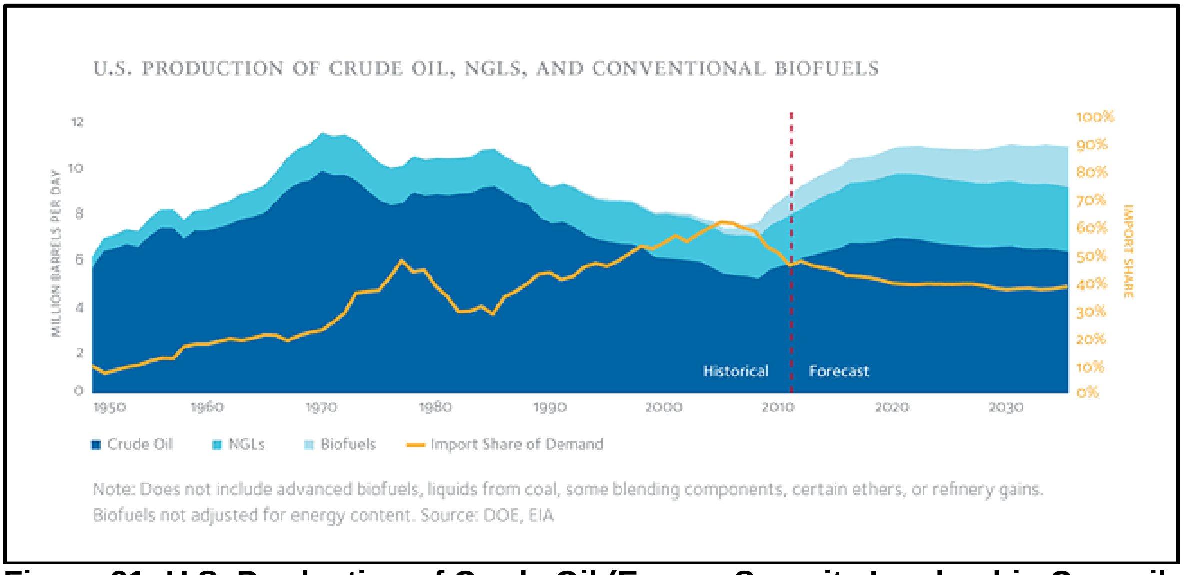


Figure 21: U.S. Production of Crude Oil (Energy Security Leadership Council 2012)

Much of this oil is expected to move via rail due to the fact that trains, although more costly than pipeline, do not require long-term contracts or need to wait for pipelines to be built. In addition, pipes stretch from A to point B, whereas refiners can access nearly any market in the U.S. by rail due to the already extensive infrastructure (Business Week 2013).

The Port of Grays Harbor is expected to move crude by rail (CBR) in the near term (2-5 years). The crude oil would travel to the Port from a variety of locations throughout the U.S., the most likely source being crude coming from the Bakken Shale located in North Dakota and Montana. Only vessels conforming to parameters of the Jones Act may carry exports of U.S. domestic crude oil. The ownership, flag, and operating parameter restrictions are such that there is a very limited inventory of vessels that qualify and are thus legally authorized to transport crude exports from Grays Harbor. This limited inventory of Jones Act tankers has the following characteristics: an Articulated Tug Barge that has a design draft of 28 feet and a tanker that would have a design draft of 36 feet. Thus, tankers capable of carrying crude exports from Grays Harbor are not presently inordinately draft-constrained, and no new class of crude-carrying tanker vessels would be newly accommodated by a channel deepened to -38 feet.

The export of Canadian crude through the Port of Grays Harbor is extremely speculative at this point but if Canadian crude were to utilize Grays Harbor the Jones Act Fleet requirement would no longer be valid. However, the fleet of vessels that are available and are expected to operate at the Port to move crude is expected to be similar regardless of the location of production of the crude. Regardless of production location of the crude the vessel size for crude is expected to be one of two options. The first would be an Articulated Tug Barge that has a design draft of 28 feet and the other is a tanker that would at most have a design draft of 36 feet. Both vessels described are capable of entering and exiting the channel in the existing conditions.

There are three proposed CBR projects at the Port of Grays Harbor as follows:

1. **Westway Terminals LLC**: Westway has proposed to expand its existing bulk liquid storage terminal at the Port of Grays Harbor to accept, store, and then ship crude oil. The proposal would accept crude oil brought to the facility by rail, store it in large tanks, and then load the crude onto ships that would take it to U.S. refineries in California or Washington (Earth Justice 2013). Westway proposes four large new storage tanks with the capacity to store a total of 800,000 barrels. Westway estimates that the terminal would receive 9.6 million barrels of oil per year.

2. **U.S. Development Group LLC**: US Development Group is proposing CBR at Terminal 3 that could potentially receive up to 50,000 barrels per day. This would be approximately one 120-car unit train delivery about every two days with approximately 45-60 vessel calls per year (US Development Group 2013). Currently Terminal 3 is underutilized with most cargo movements being forest products such as timber and woodchips. U.S. Development Group has not formally laid out the specifics of the construction or improvements that would take place at Terminal 3 but has provided a preliminary sketch of what is to be expected (Figure 22: Grays Harbor Terminal 3 Proposed Rail Terminals (U.S. Development Group 2013)).

Figure 22: Grays Harbor Terminal 3 Proposed Rail Terminals (U.S. Development Group 2013)

3. **<u>Imperium Terminals Services LLC</u>:** The Imperium group proposed a CBR facility at Terminal 1 with a capacity to receive 78,000 barrels per day. Imperium submitted permit applications for construction of new storage tanks, rail infrastructure and office space. These permits will provide Imperium the opportunity to develop an additional 10.7 acres that are within the Port of Grays Harbor and are adjacent to the existing Imperium biodiesel plant at Terminal 1(Imperium Renewables 2013).

For purposes of this economic analysis, all three proposals are assumed to move forward by late 2014 with a brief ramp up period from 2015 through 2017. For purposes of benefit analysis and modeling the ATB's (design draft of 28 feet) and the petroleum (approximately 50% of total petroleum tonnage) associated with them were taken out of the modeling used in the BCR but will be included in the SEIS. The total number of vessels needed to move all crude, to include the aforementioned removal of ATB's, will still be displayed in the total vessel count that is expected to call on the Port (Table 14). Because these vessels are not draft constrained they are excluded from the modeling that informs the benefit-cost analysis used to justify the project.

As of May 2014, permits have been submitted and a Mitigated Determination of Non-Significance was issued by the City of Hoquiam and the Washington Department of

Ecology for the Westway Terminal Company. A Mitigated Determination of Non-Significance was issued and the Shoreline Substantial Development Permit was issued in June of 2013 for the Imperium Terminal Services, LCC. The third proposal by Grays Harbor Rail Terminal (US Development Group) has been granted the Option to Lease Terminal 3 by the Port Commission for an additional 24 months to allow for further analysis and additional time to obtain permits to bring their proposed project to shovel ready status. The project status of the proposed crude oil facilities are as follow:

Westway Terminal Company
January 2014, self-initiated Environmental Impact Statement (EIS) for proposed project.

Imperium Terminal Services, LLC
January 2014, self-initiated Environmental Impact Statement (EIS) for proposed project.

Grays Harbor Rail Terminal (US Development)
April 2014, permit applications and SEPA checklist submitted to City of Hoquiam.

After 2017 the growth of petroleum exports at the Port are expected to follow the commodity projections from the WSDOT Marine Cargo Forecast of approximately .2% per year. After 2037 the growth projections are to be held constant based on the assumption that as time elapses the projections become less accurate due to uncertainty in what the future conditions may be (Figure 23: Petroleum Forecast).

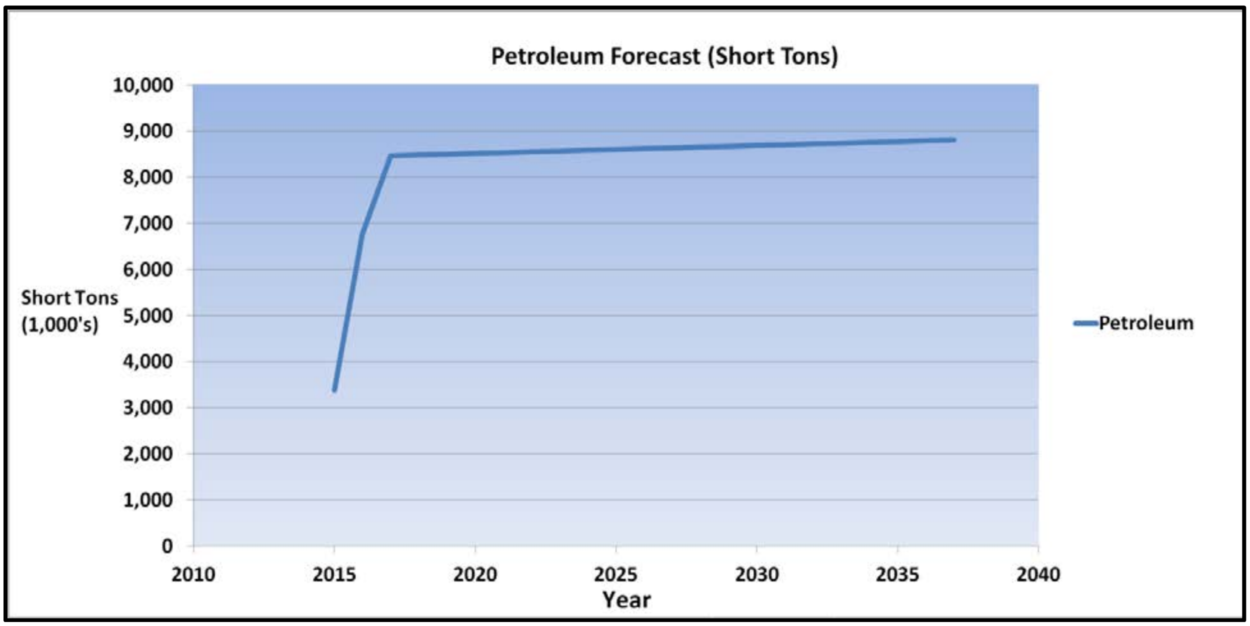


Figure 23: Petroleum Forecast

4.2.2 Soybean

In 2010, soybeans represented the U.S.'s top agricultural export with China and Mexico being the two largest recipients of U.S. soybeans (Nebraska Soybean Board 2012).

Pacific Northwest grain and oilseed have shown impressive growth over the past decade, growing from approximately 20 million metric tons in 2000 to 34 million metric tons in 2010 (Associates, BST; IHS Global Insight; Mainline Management Inc. 2011).

In 2012, a record setting 1.69 million metric tons of soybean products were exported through the Port of Grays Harbor to international markets including China, Japan, Philippines, Indonesia, Vietnam and Australia. The increase in export activity in soybean products and other dry agriculture cargos has also been accompanied by increased exports in autos, liquid bulks and forest products (Port of Grays Harbor 2013).

The category Food and Farm Products was used to consolidate grain, oilseed, and soybean into one category. In the base year 2017 the category Food and Farm Products, under the moderate growth assumption, is expected to be approximately 1.4 million short tons and have a CAGR of .7% (Table 10: Port of Grays Harbor Food & Farm Products Growth Forecast). This was taken from the WSDOT Marine Cargo Forecast (Associates, BST; IHS Global Insight; Mainline Management Inc. 2011).

Table 10: Port of Grays Harbor Food & Farm Products Growth Forecast

Port of Grays Harbor Food & Farm Products Growth Forecast							
Commodity	2017	2027	2037	2047	2057	2067	CAGR
Food & Farm Products Moderate	1,445,873	1,550,332	1,662,339	1,662,339	1,662,339	1,662,339	0.70%

4.2.3 Forest Products

The Port of Grays Harbor relied heavily, up until recently, upon lumber and forest products to sustain business. Two decades ago, shifting global demand from U.S. timber to less-costly sources from Russia and New Zealand put the Port of Grays Harbor's future in jeopardy (Millman 2011). This can be attributed in large part to the listing of the Northern spotted owl to the endangered species list in June 1990. The listing prevented the timber industry from clearing lands within a 1.3 mile radius of any spotted owl nest or activity site (Andre and Velasquez 1991). Harvest of timber in the Pacific Northwest was reduced by 80%, decreasing the supply of lumber and increasing prices (Brokaw 1996).

Once the leading export port for U.S. grown timber, Grays Harbor now leads the U.S. in exports of American grown soybean meal and is the number one seafood landing point in Washington State. While forest products remain an important piece of the Grays Harbor cargo mix, the Port has substantially diversified the products shipped through this Pacific Northwest gateway to include automobiles, biodiesel and other liquid and dry bulk products (Port of Grays Harbor 2013).

The Port of Grays Harbor saw a sharp decrease in the tonnage of forest products moved through the port during the mid 90's and consistently saw a decreasing trend in tonnage. This is attributed to the listing of the spotted owl to the endangered species list but other factors such as the Asian financial crisis, that substantially reduced U.S. exports to Asia, added to the decline in demand for forest products. This trend is expected to turn in favor of higher tonnage and demand is expected to see an improvement due to the Global and U.S. market recovery. The moderate growth forecast for Forest Products is expected to see an increase of approximately CAGR of 1.2% of the next 30 years (Table 11: Port of Grays Harbor Forest Products Growth Projections).

Table 11: Port of Grays Harbor Forest Products Growth Projections

Port of Grays Harbor Forest Products Growth Forecast							
Commodity	**2017**	**2027**	**2037**	**2047**	**2057**	**2067**	**CAGR**
Forest Products	**267,290**	**301,153**	**339,307**	**339,307**	**339,307**	**339,307**	**1.20%**

4.2.4 Manufactured Equipment (Vehicles)

The Port of Grays Harbor has become a major exporter of domestically produced Chrysler and Jeep vehicles. This began with the signing of a 20 year lease agreement with Pasha Automotive Services in 2009, an automotive exporter based in California, and has since increased year over year. Pasha shipped approximately 71,000 Chrysler vehicles in 2012 and is expecting to export approximately 100,000 in 2013(Wilhelm 2013).

The vehicles, along with manufactured heavy equipment, are being exported to Asia (China, Japan, and South Korea). The vehicles arrive by rail and are loaded on Roll-on Roll-off vessels at Terminal 4. According to the WSDOT Marine Cargo Forecast fully assembled autos will exhibit rapid growth with a moderate CAGR of approximately 3.9% and a high CAGR of approximately 4.9% (Table 12: Port of Grays Harbor Manufactured Equipment Growth Projections). The moderate CAGR of 3.9% was used for the economic analysis and was taken out 20 years (2017-2037) at which point the growth was assumed to remain constant due to the uncertainty involved in forecasting far out into the future.

Table 12: Port of Grays Harbor Manufactured Equipment Growth Projections

Port of Grays Harbor Manufactured Equipment Growth Forecast							
Commodity	**2017**	**2027**	**2037**	**2047**	**2057**	**2067**	**CAGR**
Manufactured Equipment	**191,913**	**281,358**	**412,492**	**412,492**	**412,492**	**412,492**	**3.90%**

5 Future With and Without Project Vessel Movements

The increased volume in commodities moved through the Port during the 50-year period of analysis described previously is expected to be enabled by an increase in the number of vessels over the same period. An increase in vessel traffic anticipated over time in any of the three alternatives would not be caused by the deepening action, because channel dimensions are not a present or expected limiting factor on cargo growth, and the vessel traffic increase is expected to occur independent of the deepening because of the growth in commodity volume. Thus, cargo tonnage and numbers of vessel transits are both expected to grow, under both the future without-project condition and the future with-project condition. As described in section 23.2, the volume of cargo throughput in each year over the 50-year period of analysis under the future without-project condition is expected to be the same as the cargo volume in the corresponding year under the future with-project condition. The independent commodity growth estimates were mostly derived from the Washington State Marine Cargo forecast (Associates, BST; IHS Global Insight; Mainline Management Inc. 2011). These commodity growth forecasts were applied to the Port of Grays Harbor's existing commodities to get an aggregate tonnage expected to move through the Port during the 50 year life of the project. For purposes of this economic analysis, a conservative approach is taken utilizing this source's moderate growth projections, to reduce the possibility of overstating the economic benefits of project implementation. Note that, by contrast, different growth projections are used in the SEIS: in that NEPA document, optimistic growth projections are used to evaluate the environmental consequences of the preferred alternative. The SEIS's environmentally conservative approach reduces the possibility of understating the potential effects of project implementation on the quality of the human environment for purposes of NEPA analysis. The total tonnage and commodity types were used to put together a fleet forecast using the Bulk Loader Tool[24] to calculate the number of vessels needed to satisfy the commodity demand at the Port (Figure 24: Commodity Tonnage and Vessel Call List Process). The independent commodity growth estimates are expected to be adhered to during the project. That is to say that growth estimates above and beyond what is in the independent commodity estimates or from other sources are not expected to occur. In addition, the total vessels needed to move the specific cargo during the project life is expected to be at its highest during the without project condition (i.e. Alternative 1) and see a decline in the number of vessels needed to move the same amount of cargo due to efficiencies attributed to the implementation of the project (i.e. Alternative 2 or Alternative 3). Because an economically conservative moderate growth projection is used here for economic analysis purposes, while an environmentally conservative optimistic growth projection is used in the SEIS for environmental effects analysis purposes, the projection of future with-project condition vessel movements under Alternative 3 will be different in the SEIS.

[24] The Bulk Loader Tool is an integrated module within Harborsym designed to generate synthetic vessel call lists based upon user provided calling statistics. These statistics include information on tonnage, commodity type, and vessel characteristics.

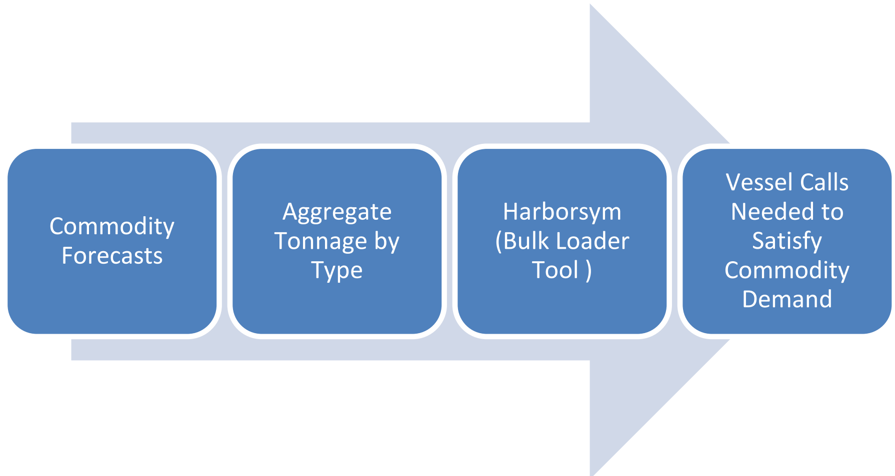


Figure 24: Commodity Tonnage and Vessel Call List Process

In addition, the future with and without project vessel origin and destination are expected to be the same, and the overall size and type of vessels will remain relatively unchanged regardless of whether a deepening project is implemented.[25] The vessel fleet (size and type) was held reasonably constant for multiple reasons; based on information provided by the Port, and commodity tonnage forecast, a need for changes to the existing fleet beyond the increase in vessel port call numbers projected to occur independently of implementation of either Alternative 2 or Alternative 3 would be unnecessary to handle the commodities expected to transit Grays Harbor. In addition, the introduction of larger vessels, those beyond what are already calling, would reintroduce the inefficiencies the recommended project is intended to alleviate.[26] A movement to these larger vessels would require these vessels to light load and or tide ride to utilize the existing channel, thus reintroducing higher transportation cost.

[25] The without project condition is defined as without further deepening – i.e. currently implemented and maintained project of -36 feet MLLW.

[26] Currently, a mix of break bulk, dry bulk, roll-on/roll-off (Ro-Ro), barge, and tanker vessels call at the Port, the largest of which are Panamax vessels (50,001 – 80,000 dwt), which have a maximum length overall of 965 ft , 106 ft beam, and 39.5 ft draft in order to fit through the Panama Canal. Although Panamax vessels currently call at the Port, they cannot fully load and/or must wait for high tides to transit due to insufficient channel depth. Deepening the navigational channel from -36' to -38' MLLW will allow for more efficient operation of Panamax vessels. However, because the industry does not operate a discrete size category of vessels within the band between a 36-foot draft and a 39.5-foot draft, deepening is not anticipated to allow for larger bulk or tanker vessel classes to call at the Port as doing so would reintroduce the inefficiencies (light loading and tide riding) that the deepening is intended to alleviate. Ro-Ro vessels, with a draft of no more than 32 feet, are not generally depth limited at the Port, dependent on underkeel clearance requirements. Larger bulk classes such as Capesize (typically 175,000 dwt, but up to 400,000 dwt), with a draft of 60 feet and deeper, or larger tankers, such as Aframax (80,000 – 119,000 dwt), with a typical 60-foot draft, would not be expected to call at the Port at a -38-foot MLLW depth. Larger containerized vessels, such as Post-Panamax vessels, requiring 45 feet of depth, are not expected to call at the Port due to lack of container terminals, cranes, and other specialized facilities necessary to accommodate said cargo.

The future fleet is developed through the use of HarborSym and the Bulk Loader Tool (BLT). The BLT is designed to process two unique steps to generate a shipment list for use in a HarborSym analysis. First, a synthetic fleet of vessels is generated that can service the port. This fleet includes the maximum possible vessel calls based on the user provided availability info. Second, the commodity forecast demand is allocated to individual vessels from the generated fleet, creating a vessel call and "using up" an available call from the synthetic fleet. Additional details on each of these steps can be found in the HarborSym Application User's Manual from IWR. The vessel call database is then put into HarborSym to run. The BLT uses historic vessel statistics to develop departure drafts.

While the estimated volume of commodities is expected to increase over time, the estimated volume of commodities is projected to be approximately the same in any given year of the 50-year period of analysis between Alternative 1, Alternative 2 and Alternative 3. Growth in cargo throughput volumes is thus independent of project implementation. This information is discerned from the observation that the vessel fleet (size and type) would remain relatively the same due to the aforementioned reintroduction of inefficiencies that would prevail with the change to a larger vessel. The additional two feet of depth, after reviews of the existing world fleet, does not indicate a need or reason to change to a different vessel type. The economic analysis shows that the number of vessels decreases from Alternative 1 to Alternative 2, and from Alternative 2 to Alternative 3 in any given year in the 50-year period of analysis because the additional depth provided under either Alternative 2 or Alternative 3 would allow each vessel to carry more goods on average. Fewer vessels moving the same amount of goods is a transportation cost savings, which is counted as an economic benefit for this analysis. In addition, vessels that are expected to traverse the channel would gain efficiencies by experiencing a reduction in delays associated with tide. The reduction in delays are attributable to an increase in the available time to utilize the tide fluctuations due to additional depth under Alternatives 2 and 3, and are also attributable to relief in traffic congestions due to a reduction in the number of vessels (vessel traffic) traversing the channel.

The future with and without project vessel movements were created through the use of the Bulk Loader Tool (BLT) in HarborSym. The total tonnage moved throughout the 50-year analysis for the with and without project conditions used in the modeling were the same. The caveat is that the use of HarborSym (Monte Carlo simulation) there are some minor discrepancies with respect to the exact tonnage between project comparisons once the model has completed all iterations. Relatively speaking the difference was minute and is not expected to affect the plan selection.

The future vessel calls were estimated by applying the forecasted commodity tonnage for each commodity type, developed through the use of regional reports, lease agreements and qualitative data, to a fleet distribution that minimizes total transportation costs. The BLT does this by utilizing the most efficient mix of vessel sizes that take full advantage of increased channel depth in the future with project conditions. Tables 13-15 below summarize estimated vessel traffic, and show the decrease in estimated number of vessels in any given year, when comparing the without project condition and the two with project conditions.

Table 13: Total Vessel Calls

Estimated Vessel Calls (Entire Forecasted Commodity Tonnage)					
2017 Without Project		**2017 With Project -37MLLW**		**2017 With Project -38MLLW**	
VesselClass	**Calls**	**VesselClass**	**Calls**	**VesselClass**	**Calls**
ATB 30k	122	ATB 30k	122	ATB 30k	122
Bulker 30k	4	Bulker 30k	4	Bulker 30k	4
Bulker 40k	5	Bulker 40k	5	Bulker 40k	5
Bulker 50k	15	Bulker 50k	10	Bulker 50k	9
Bulker 60k	22	Bulker 60k	22	Bulker 60k	22
Bulker 80k	3	Bulker 80k	3	Bulker 80k	3
Ro-Ro 10k	22	Ro-Ro 10k	22	Ro-Ro 10k	22
Ro-Ro 20k	8	Ro-Ro 20k	8	Ro-Ro 20k	8
Tanker-Medium	130	Tanker-Medium	126	Tanker-Medium	123
Tanker-Small	7	Tanker-Small	7	Tanker-Small	7
Total	**338**		**329**		**325**
2027 Without Project		**2027 With Project- 37MLLW**		**2027 With Project -38MLLW**	
VesselClass	**Calls**	**VesselClass**	**Calls**	**VesselClass**	**Calls**
ATB 30k	134	ATB 30k	134	ATB 30k	134
Bulker 30k	6	Bulker 30k	6	Bulker 30k	6
Bulker 40k	7	Bulker 40k	7	Bulker 40k	6
Bulker 50k	9	Bulker 50k	8	Bulker 50k	5
Bulker 60k	25	Bulker 60k	25	Bulker 60k	24
Bulker 80k	5	Bulker 80k	5	Bulker 80k	5
Ro-Ro 10k	19	Ro-Ro 10k	19	Ro-Ro 10k	19
Ro-Ro 20k	17	Ro-Ro 20k	17	Ro-Ro 20k	17
Tanker-Medium	132	Tanker-Medium	128	Tanker-Medium	126
Tanker-Small	13	Tanker-Small	13	Tanker-Small	13
Total	**367**		**362**		**355**
2037 Without Project		**2037 With Project -37MLLW**		**2037 With Project -38MLLW**	
VesselClass	**Calls**	**VesselClass**	**Calls**	**VesselClass**	**Calls**
ATB 30k	149	ATB 30k	149	ATB 30k	149
Bulker 30k	6	Bulker 30k	6	Bulker 30k	6
Bulker 40k	9	Bulker 40k	9	Bulker 40k	9
Bulker 50k	6	Bulker 50k	4	Bulker 50k	4
Bulker 60k	25	Bulker 60k	25	Bulker 60k	25
Bulker 80k	8	Bulker 80k	8	Bulker 80k	6
Ro-Ro 10k	20	Ro-Ro 10k	20	Ro-Ro 10k	20
Ro-Ro 20k	28	Ro-Ro 20k	28	Ro-Ro 20k	28
Tanker-Medium	134	Tanker-Medium	130	Tanker-Medium	127
Tanker-Small	15	Tanker-Small	15	Tanker-Small	15
Total	**400**		**394**		**389** [27]

[27] The reader will note a difference in the number of vessels expected to traverse the channel in the Economic Appendix versus the SEIS. Optimistic growth rates, although highly unlikely, in commodities

Table 14: Vessel Calls Without ATB's

Estimated Vessel Calls (Without ATB's)					
2017 Without Project		**2017 With Project -37MLLW**		**2017 With Project -38MLLW**	
VesselClass	**Calls**	**VesselClass**	**Calls**	**VesselClass**	**Calls**
Bulker 30k	4	Bulker 30k	4	Bulker 30k	4
Bulker 40k	5	Bulker 40k	5	Bulker 40k	5
Bulker 50k	15	Bulker 50k	10	Bulker 50k	9
Bulker 60k	22	Bulker 60k	22	Bulker 60k	22
Bulker 80k	3	Bulker 80k	3	Bulker 80k	3
Ro-Ro 10k	22	Ro-Ro 10k	22	Ro-Ro 10k	22
Ro-Ro 20k	8	Ro-Ro 20k	8	Ro-Ro 20k	8
Tanker-Medium	130	Tanker-Medium	126	Tanker-Medium	123
Tanker-Small	7	Tanker-Small	7	Tanker-Small	7
Total	**216**		**207**		**203**
2027 Without Project		**2027 With Project- 37MLLW**		**2027 With Project -38MLLW**	
VesselClass	**Calls**	**VesselClass**	**Calls**	**VesselClass**	**Calls**
Bulker 30k	6	Bulker 30k	6	Bulker 30k	6
Bulker 40k	7	Bulker 40k	7	Bulker 40k	6
Bulker 50k	9	Bulker 50k	8	Bulker 50k	5
Bulker 60k	25	Bulker 60k	25	Bulker 60k	24
Bulker 80k	5	Bulker 80k	5	Bulker 80k	5
Ro-Ro 10k	19	Ro-Ro 10k	19	Ro-Ro 10k	19
Ro-Ro 20k	17	Ro-Ro 20k	17	Ro-Ro 20k	17
Tanker-Medium	132	Tanker-Medium	128	Tanker-Medium	126
Tanker-Small	13	Tanker-Small	13	Tanker-Small	13
Total	**233**		**228**		**221**
2037 Without Project		**2037 With Project -37MLLW**		**2037 With Project -38MLLW**	
VesselClass	**Calls**	**VesselClass**	**Calls**	**VesselClass**	**Calls**
Bulker 30k	6	Bulker 30k	6	Bulker 30k	6
Bulker 40k	9	Bulker 40k	9	Bulker 40k	9
Bulker 50k	6	Bulker 50k	4	Bulker 50k	4
Bulker 60k	25	Bulker 60k	25	Bulker 60k	25
Bulker 80k	8	Bulker 80k	8	Bulker 80k	6
Ro-Ro 10k	20	Ro-Ro 10k	20	Ro-Ro 10k	20
Ro-Ro 20k	28	Ro-Ro 20k	28	Ro-Ro 20k	28
Tanker-Medium	134	Tanker-Medium	130	Tanker-Medium	127
Tanker-Small	15	Tanker-Small	15	Tanker-Small	15
Total	**251**		**245**		**240** [28]

were applied to the environmental and socioeconomic impacts associated with this analysis so as to be conservative with respect to the environmental impacts (See 4.0.3.1 Induced Economic Growth, SEIS).

[28] For the benefit analysis and modeling purpose the ATB's (design draft of 28 feet) and the petroleum (approximately 50% of total petroleum tonnage) associated with them were taken out of the modeling used in the BCR but will be included in the SEIS.

6 National Economic Development Plan Analysis

The base economic benefit of a navigation project is the reduction in the value of resources required to transport commodities. National Economic Development (NED) deep-draft navigation benefits generally fall into 3 major groups:

1. Reduced cost of transportation
2. Shift in origin or destination
3. Increased net return to producers from access to new sources of lower cost materials

For this particular project most of the expected benefits were taken from the cumulative reduction in transportation cost over the 50 year period of analysis. Benefits attributed to transportation cost savings are due to the elimination of vessel calls or reduction in transit times as a result of more efficient vessel loadings, use of alternative mode (land versus water), and/or anticipated net reductions in vessel accident rates between the without and with project conditions. Transportation delays awaiting high tides or vessel congestion are accounted for through the use of the HarborSym modeling. Using the model we can calculate the cost of these delays and any changes in overall transportation costs resulting from proposed modifications to the channel's physical dimensions or sailing restrictions.

NED benefits will be assessed for the alternatives identified in the Problems/Opportunities section following the methodology prescribed by Corps Planning Guidance Notebook for deep draft economic analysis (IWR 2010).

Benefits are equal to the difference between without and with project transportation cost. All transportation costs are adjusted to the base year of the project, 2017, and are then converted to Average Annual Equivalent (AAEQ) values using the Fiscal Year (FY) 2012 Federal discount rate of 3.5 percent, assuming a 50-year study period. All project costs and benefits are at 3rd Quarter 2017 price levels. The benefits estimated for the separable elements of each alternative will be compared to its cost to determine its economic justification. The plan that maximizes net benefits (benefits less cost) is the NED Plan. [29].

6.1 Methodology

Transportation cost savings were calculated using the HarborSym model. The USACE Navigation Economic Technologies website (www.corpsnets.us/harborsym/) describes HarborSym as follows:

This model is a planning-level simulation designed to assist in the economic analysis of coastal harbors. With user provided input data, such as the port layout, vessel calls, and

[29] NED analysis generally analyzes a suite of alternatives but for Grays Harbor the analysis was constrained, at the request of the sponsor, to -37 and -38 MLLW. Thus the plan recommended, under the constraints, is the plan that maximized the net benefits and not necessarily what is traditionally thought of as the NED maximizing plan.

transit rules, the model calculates vessel interactions within the harbor. Unproductive wait times result when vessels are forced to delay sailing due to transit restrictions within the channel; HarborSym captures these delays. Using the model, analysts can calculate the cost of these delays and any changes in overall transportation costs resulting from proposed modifications to the channel's physical dimensions or sailing restrictions. Developed as a data driven model, HarborSym allows users to analyze changes without modifying complex computer code. This approach also enables analysts to apply the model to many different ports by altering the network representation of the harbor.

Specific procedures, assumptions and parameters for estimating vessel utilization savings (deepening benefits), vessel operational times savings (delay reduction benefits), and benefits during construction are discussed in the BENEFITS section of this Appendix. In addition, footnotes are placed where applicable to identify sources and any assumptions used throughout the analysis.

6.2 Model Setup and Inputs

The model setup and inputs for Grays Harbor followed a step by step approach that can be summarized as follows:

1. **Setting up Grays Harbor Basic Parameters:** The initial step to using HarborSym to simulate any study is to create a new study in the system and fill in the key parameters such as the port location via longitude and latitude. The exact inputs for Grays Harbor can be found below in figure 25 –Grays Harbor Study Manager.

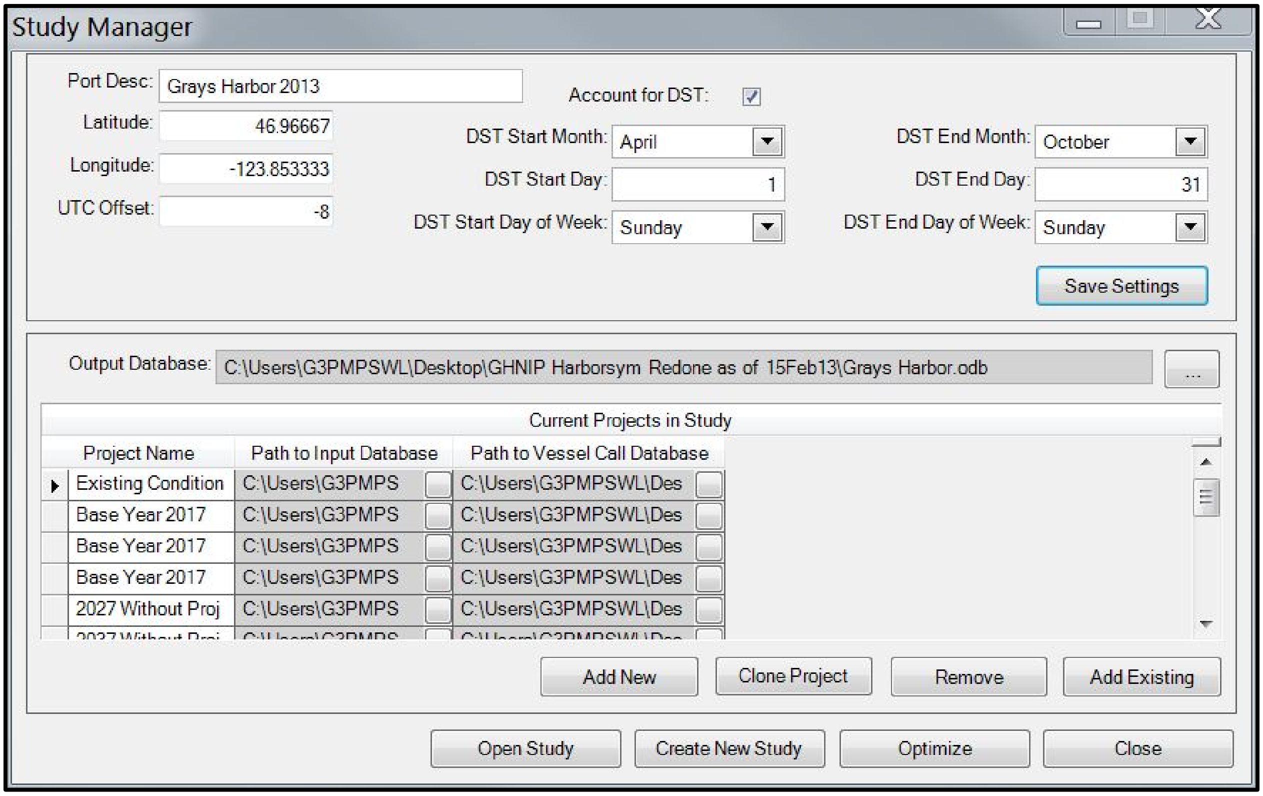


Figure 25: Grays Harbor Study Manager

2. **Building the Grays Harbor Network**: HarborSym is represented by a linked node network and as such each Harbor has a distinct node network. The nodes represent physical characteristics such as turning basins[30], entrances, exits, and terminals at the port (Figure 26: Grays Harbor Network and Nodes). Once these key features are populated into HarborSym the specific characteristics to define the feature are entered.

[30] There is one turning basin authorized at Grays Harbor and all traffic is expected to utilize this turning basin. Smaller vessels may not use this turning basin but for simplicity in the modeling it is assumed that all vessel entering and exiting the Port of Grays Harbor utilize the single turning basin.

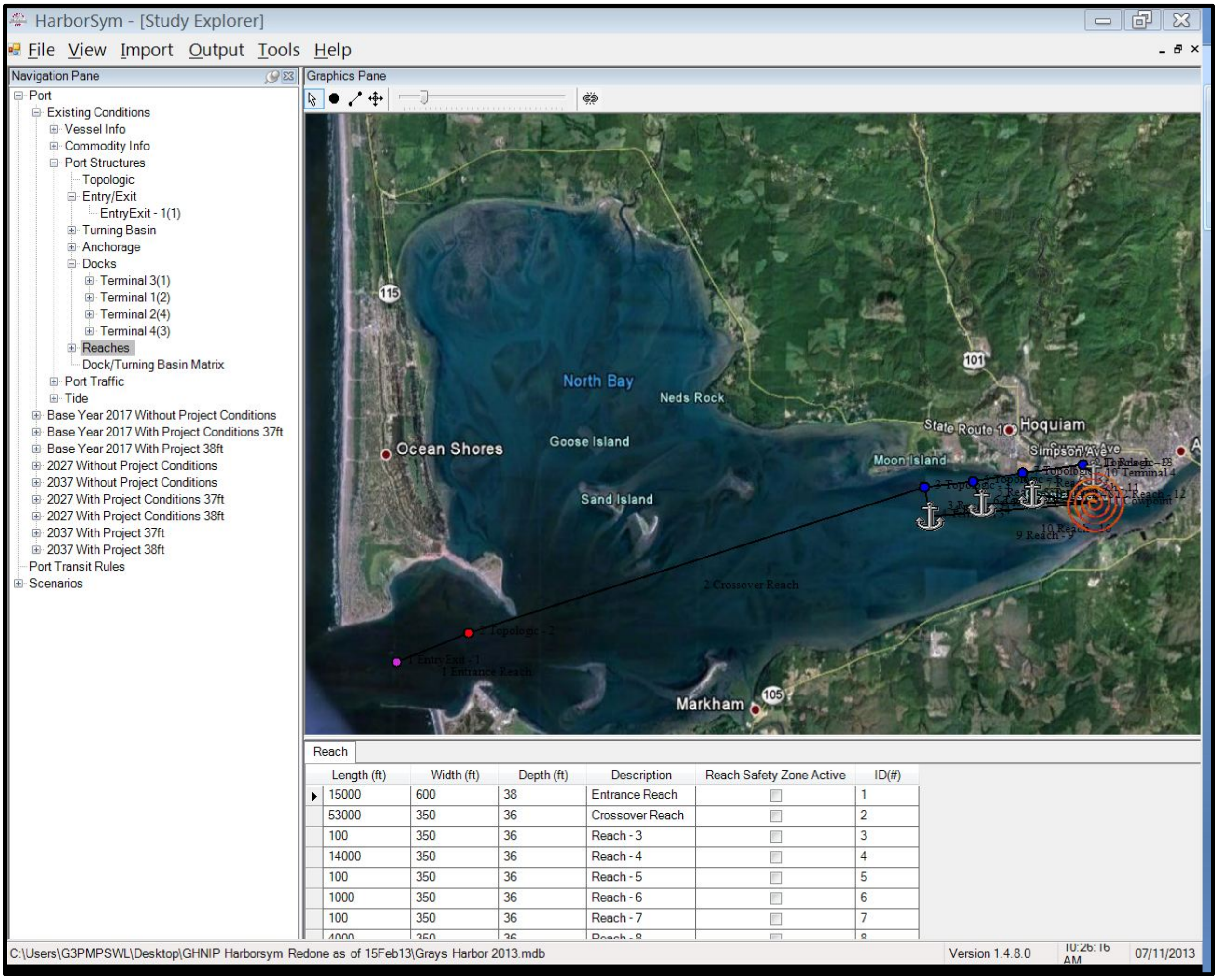


Figure 26: Grays Harbor Network and Nodes

3. **Define Vessel Types and Classes Operating in Grays Harbor**: Harborsym requires that you enter the key vessels operating in the harbor as well as the key characteristics of those vessels (length, beam, design draft, and capacity). Tanker, Bulker, and Ro-Ro[31] are the three main vessel types operating at Grays Harbor (Figure 27: Grays Harbor Vessel Types). For specifics of the type of vessels used at Grays Harbor reference section 3.4 Existing Vessel Fleet.

[31] For Ro-Ro vessels one size was utilized to move vehicles throughout the 50 year analysis. The reason is that the Ro-Ro vessels entering Grays Harbor have very similar characteristics and are not expected to have a major deviation in size in the future.

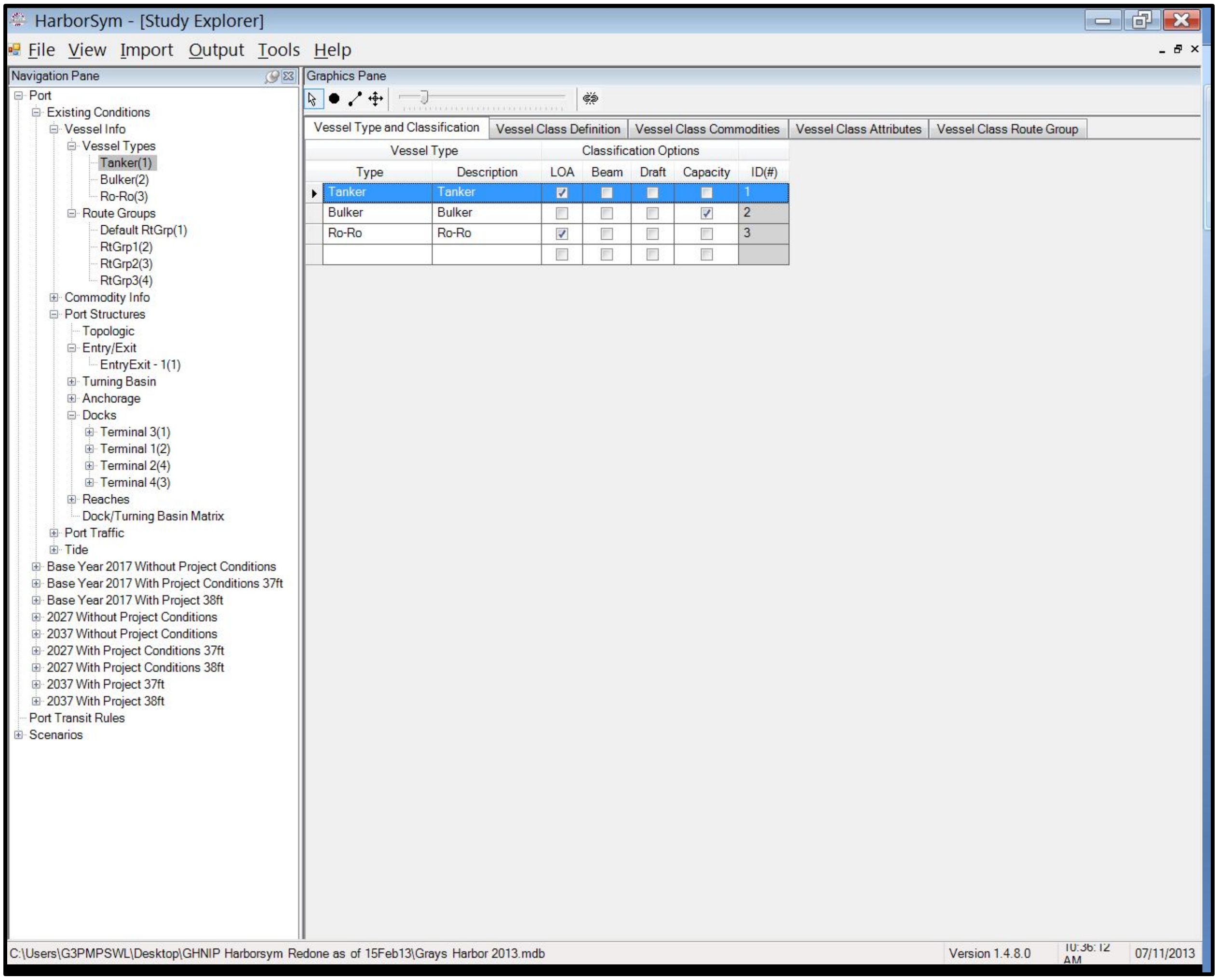


Figure 27: Grays Harbor Vessel Types

4. **Define Route Groups**: The route groups for Grays Harbor are displayed above in the section **Origins and Destination (Section 3.3)**.

5. **Define the Commodities:** Harborsym requires the user to input the commodity categories along with the units of measure and values per unit (Figure 28: Grays Harbor Commodity Categories). More about the commodities being moved through the Port of Grays Harbor can be found previously in Historic and Existing Commodity Movements (Section 3.2) and Future Commodity Movements (Section 4.2).

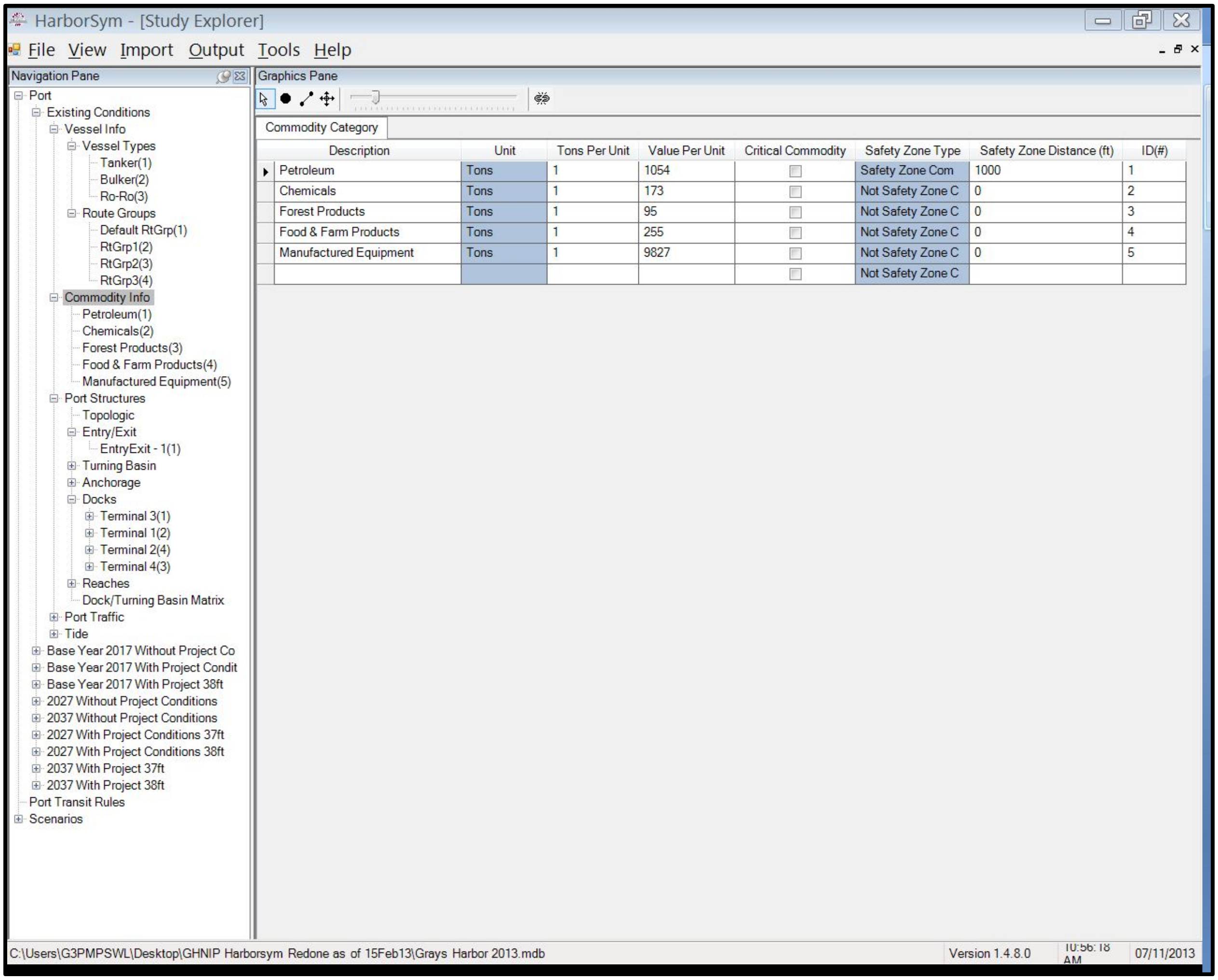


Figure 28: Grays Harbor Commodity Categories

6. **Define Vessel Speeds, and Commodity Transfer Rate:** Vessel speed and docking times were taken from historic information and direct interviews with the Harbor Pilots that operate in Grays Harbor[32]. The transfer rates, found in Table 16 below, for each commodity were derived from Grays Harbor Pilot Logs that show the arrival and departure time. In addition, the Pilot Logs display the tonnage and cargo for each vessel that called in 2012. This data was then input into Harborsym as a key component to deriving total cost of operations at the Port of Grays Harbor.

[32] The time in reaches and at the dock were taken from hard data provided by the Port and the Pilots and as such was not rechecked by the Pilots or Port Authority.

Table 15: Commodity Transfer Rates

Commodity Transfer Rates Terminal 1							
		Loading Rate (Short Tons/Hour)			Unloading Rates (Short Tons/Hour)		
Vessel Type	Commodity	Min	Most likely	Max	Min	Most Likely	Max
Tanker	Petroleum	1000	2000	3000	1000	2000	3000
Tanker	Chemicals	427	540	613	427	540	613
Bulker	Forest Products, Wood & Wood Chips	290	396	603	290	396	603
Bulker	Food & Farm Products	86	360	1222	86	360	1222
Commodity Transfer Rates Terminal 2							
		Loading Rate (Short Tons/Hour)			Unloading Rates (Short Tons/Hour)		
Vessel Type	Commodity	Min	Most likely	Max	Min	Most Likely	Max
Tanker	Petroleum	1000	2000	3000	1000	2000	3000
Tanker	Chemicals	427	540	613	427	540	613
Bulker	Forest Products, Wood & Wood Chips	290	396	603	290	396	603
Bulker	Food & Farm Products	86	360	1222	86	360	1222
Commodity Transfer Rates Terminal 3							
		Loading Rate (Short Tons/Hour)			Unloading Rates (Short Tons/Hour)		
Vessel Type	Commodity	Min	Most likely	Max	Min	Most Likely	Max
Tanker	Petroleum	1000	2000	3000	1000	2000	3000
Tanker	Chemicals	427	540	613	427	540	613
Bulker	Forest Products, Wood & Wood Chips	290	396	603	290	396	603
Bulker	Food & Farm Products	86	360	1222	86	360	1222
Commodity Transfer Rates Terminal 4							
		Loading Rate (Short Tons/Hour)			Unloading Rates (Short Tons/Hour)		
Vessel Type	Commodity	Min	Most likely	Max	Min	Most Likely	Max
Tanker	Petroleum	1000	2000	3000	1000	2000	3000
Tanker	Chemicals	427	540	613	427	540	613
Bulker	Forest Products, Wood & Wood Chips	290	396	603	290	396	603
Bulker	Food & Farm Products	86	360	1222	86	360	1222
Ro-Ro	Manufactured Equip (Cars)	74	792	2440	74	792	2440

7. **Create Historical Call List:** The historic call list for Grays Harbor was taken from the Pilot Logs and Port Vessel Call information provided by the Port for the operating year of 2012. To protect proprietary information associated with the Port and its associated business partnerships the specific call list has been removed from this appendix.

8. **Cloning Project and Simulating Port Traffic**: The historical conditions are used to build the base year, 2017 for Grays Harbor, that is then used as the seed to clone future conditions. The cloning feature of HarborSym is mainly used as a tool to avoid having to repopulate all the data populated in steps 1-7 for each year of analysis. The simulations were 100 iterations with a consistent seed number of 6 for the Monte Carlo simulation. The 100 iterations for each model run are to ensure that the standard deviation is minimized in the model. That is the more iteration run the more the model stabilizes. The main changes made for each future conditions alternative was the adjustment of the depth available for transit along the main channel for each reach[33]. For example, in the -37 MLLW alternatives the depth of the channel for each reach was adjusted from -36 MLLW to -37 MLLW. This was also done for -38 MLLW so as to account for the change in the channel depth.

[33] The only Reach not adjusted for depth was the Entrance Reach as it is naturally deeper and is equal to or greater than the depth of all alternatives under consideration.

9. **Create a Synthetic Vessel Call List in BLT**: The Bulk Loading Tool (BLT) generates the synthetic vessel call list based off of the statistical information derived from the existing vessel call list along with a commodity forecast for each year analyzed and a total number of calls, by vessel class. The BLT was used to create the future call list for each project alternative.

6.2.1 Key Assumptions

With any modeling and or planning projects assumptions must be made in order to facilitate the decision making process. The key assumptions that were made for this project are as follows:

- The Port, based on infrastructure improvement projects totaling approximately $200 million dollars over the past decade, is expected to be able to accommodate the tonnage forecasted over the 50 year period of analysis[34].
- The vessel types (Tanker, Bulker, ATB's, and Ro-Ro) do a reasonable job of capturing the size and type of vessel utilizing the Port of Grays Harbor.
- Vessel sizes were held reasonably constant during the economic analysis for ease of modeling[35]. This is not expected to change the outcome of the recommended alternative due to the fact that generally as vessel sizes increase and with that an increase in the volume of commodities carried so too does the economies of scale.
- Vessels of similar type and cargo are expected to have similar dock, undock, load, and unload rates.
- Vessels operating in the system do not have mechanical or human failure.
- The vessel route group (East Asia, Asia, and North America) captures most of the traffic utilizing the Port of Grays Harbor.
- Channel dimensions are not a present or expected limiting factor on projected cargo growth[36].
- The future with and without project vessel origin and destination are expected to be the same[37] as the base year 2017.
- The petroleum projected to be moved in the base year falls into the North America Route Group.
- Commodities would remain relatively the same throughout the 50-year period of analysis.

[34] In 1986, prior to the spotted owl being an ESA listed species, the port moved approximately 4.5 to 4.6 million tons. This represents almost half of what is projected 20 years from now and was moved prior to millions of dollars of infrastructure improvements.

[35] Based on Vessel Trends that can be found in the Supplemental Environmental Impact Statement the Port has seen an historical increase in the overall size of vessels being utilized in the channel.

[37] Based on lease agreements and continued world demand for agricultural products the current customers of the Port of Grays Harbor are expected to continue business with the Port via its current resident companies.

- Demand for commodities is expected to grow slightly over the 50-year period of analysis.
- Commodity forecast were held constant after 2037 due to the expectation that predictions become less accurate as time elapses.
- There is not expected to be a shift in destination, mode, or any induced movement of new cargo during the 50-year period of analysis.
- The tonnage transported through Grays Harbor is expected to be similar for future years under either with- or without-project conditions.
- CBR enters the commodity mix around 2015 and the demand for fossil fuels continues to grow.
- CBR is expected to transit via the Port of Grays Harbor –with or without the project.
- The interest rate of 3.5% used to do the economic analysis would remain the same over the 50-year period of analysis.
- The design under-keel clearance is 4.5 feet for all vessels utilizing the harbor and is based on expert elicitation and information from the Coastal Engineers (Engineering Appendix).
- The benefits from the project are assumed to not have an economic multiplier effect.
- Modeling in 10 year increments, as oppose to annually, over the 50-year period of analysis and interpolating does a good job of capturing the cost associated with the years in between the modeled years.
- Vessels will wait approximately 1 hour before retrying to enter the harbor or exiting a node to ensure as many vessels as possible can get through and accounted for in the system.
- The maximum time a vessel can wait in the system is approximate 8 hours before being deleted from the system.
- Once a vessel is moving within a leg it has priority over all other vessels that subsequently enter the leg.

6.2.2 Model Limitations

HarborSym is a planning tool developed to analyze deep draft navigation projects by evaluating the impact of various harbor improvements. However, like all planning models, there are limitations. Some key model limitations are:

- HarborSym requires detailed user-provided data and assumptions and relies heavily on the quality of the data available to complete the analysis.
- Cost that are accumulated outside of the actual vessels entering or exiting the harbor such as fixed cost, tug assistance cost, pilot cost, terminal fees, and externalities are not captured by the model.
- Hinterland transportation costs are not included in the model.
- External factors such as weather, emergencies, laws, or policies are not captured in the model.

6.2.3 Vessel Operating Costs

Deep-draft vessel operating cost (DDVOC) are a main component in the evaluation of economic benefits of deep-draft or coastal waterway improvement projects. Since the 1960's the DDVOCs have been developed by the USACE Institute for Water Resources and is published in the form of datasheets (IWR 2010). This helps to ensure consistency, efficiency across the nation. In addition, the provision for DDVOC helps to reduce the burden on USACE District Economist by providing standards for all deep-draft navigation studies without having to defend the development methodology.

The specific tables used to derive the DDVOCs for the Port of Grays Harbor were the Vessel Operating Cost in USACE Economic Guidance Memorandum 11-05 tables dated July of 2011(Army 2011). The HarborSym model requires the hourly domestic and foreign cost at sea and at port as an input. The DDVOC developed by IWR differentiates between domestic and foreign cost at sea or in port for the modeling it was assumed that a vessel cost would be dependent on the most likely type of vessel used and whether the vessel was in transit or at the dock. In addition, the DDVOC displays the cost associated with general characteristics whereas some of the vessels operating in Grays Harbor may or may not match up closely with said general characteristics. Where the vessel characteristics do not match up perfectly, in a few cases, the next closest similar characteristic vessel cost from the DDVOC were used.

6.3 Economic Modeling Results and Plan Selection

The economic modeling was based on the benefits derived from the reduction in overall cost throughout the 50-year period of analysis. The alternative that reasonably maximizes net benefits, per USACE guidance, should be the plan selected to be implemented. The three alternatives previously described in Section 1.7 that were analyzed include:

- Alternative 1: No Action
- Alternative 2: Deepen Channel to -37 MLLW
- Alternative 3: Deepen Channel to -38 MLLW

7 NED Costs

NED costs are defined as opportunity cost and as such may or may not come in many different forms. There are economic costs (explicit) and financial costs (implicit) that may overlap. Financial costs are synonymous with accounting costs or actual expenses. Economic costs can be an exercise in theory on how resources such as land or other national resources could better be used or the value of that which is foregone (opportunity cost).

The relevant costs for project evaluation have been determined by policy to be NED costs. The Planning Guidance Notebook (ER 1105-2-100) states that NED costs are used for the economic analysis of alternative projects and reflect the opportunity cost of direct or indirect resources consumed by project implementation.

The financial costs were provided by the Seattle District Cost Engineering Department and were developed through the Micro-Computer Aided Cost Estimating System (MCACES) 2nd generation (See Appendix E, Cost Estimate).

The annual maintenance at Grays Harbor is approximately $8-10 million for -36 feet MLLW. This dollar amount is expected to change at the alternative depths that were looked at. For comparisons, to derive the benefits, the economic analysis looked at the change in operational costs savings from Alternative 1 (-36 feet MLLW) to Alternative 2 (-37 feet MLLW) and Alternative 3 (-38 feet MLLW). The O&M for the economic analysis for the other alternatives (-37 and -38) are expected to see an incremental change. The incremental cost increase from the current operations (without project) to the -with project (-37, and -38 MLLW) were added to the total project cost. The incremental increase of alternative 2 and 3 are found in the table below (Table 16: Grays Harbor Operation and Maintenance).

Table 16: Grays Harbor Operation and Maintenance

Grays Harbor Incremental Operation and Maintenance		
Alternative	**Volume (Cubic Yards)**	**Total Cost**
Alternative 2 (-37 MLLW)	50,000	$ 272,000
Alternative 3 (-38 MLLW)	107,000	$ 590,000

Additional costs were added to account for the interest during construction (IDC) that would accrue. That is the opportunity cost of not using the funds tied up in the project for other purposes. The FY14 federal interest rate of 3.5% along with a construction period of approximately 8 months was used to derive the IDC. The NED costs for alternative 2 and 3 are found in the tables below.

Table 17: NED Costs Alternative 2 (-37 MLLW)

NED COSTS -37 MLLW	
Estimated Total Project Costs	$ 11,125,000
Interest During Construction	$ 112,000
Total	$ 11,237,000

Table 18: NED Costs Alternative 3 (-38 MLLW)

NED COSTS -38 MLLW	
Estimated Total Project Costs	$ 18,384,000
Interest During Construction	$ 186,000
Total	$ 18,570,000

8 Benefits

National Economic Development (NED) Benefits are defined as increases in the economic value of the goods and services that result directly from a project. NED benefits are increases in national wealth, regardless of where in the U.S. they occur (IWR, National Economic Development Procedures Manual: Coastal Storm Damage and Erosion 1991).

With respect to navigation, NED benefits are defined as the reduced cost of transportation (see Annual Cost Savings below). Benefits attributed to the Grays Harbor Navigation Improvement Project are mainly transportation cost savings due to the elimination or reduction in transit times, and the use of more efficient vessel loadings.
The benefits associated with more efficient vessel loading, one of four types of benefits for Deep Draft Navigation, is calculated by first determining the unit cost of "without project" condition, then determining the unit cost of "with project" condition, followed by computing the project savings over the Project Life (50 years) derived by taking the difference between the unit costs.

Let's assume for the sake of a simple example calculation that a 50,000 DWT vessel is entering the channel partially loaded at 25,000 DWT(IWR, Deep Draft Navigation IWR Report 10-R-4 2010)[38]:

Step 1) Determine unit cost of "without project" condition

Sea and port voyage costs are defined as all the costs necessary for a vessel to operate and include such things as fixed costs (crew, depreciation, and insurance), variable costs such as fuel. For the 50,000 DWT vessel, it would cost approximately $599 per hour as sea and $399 per hour at port. Assuming that the voyage from Asia is 6,000 miles and with a sailing speed of 14 knots per hour, the vessel would spend 428 hours at sea at a cost of $256,000. If the vessel remains in port for 48 hours as it unloads and reloads cargo, its port cost would be $19,000. The total cost is $275,000 ($256,000 at sea + $19,000 at port). To get the unit cost of $11.02 per ton one would divide the total cost of $275,000 by the DWT of 25,000.

Step 2) Determine unit cost of "with project" condition

The economist should determine how much more cargo that vessel could accommodate for each additional foot of deepening. The immersion factor, defined as the relationship between a change in a vessel's load and a change in its draft, can vary depending on the type of vessel. By examining the vessel's immersion factor, one foot of additional depth would enable this particular vessel to load 1,644 more tons of cargo. Since the vessel can now load more fully, the transportation costs drop. The unit cost of $10.34 per ton for going one more foot is found by taking the total cost of $275,000 and divided it by the new tonnage of 26,644 (25,000 DWT + 1,644 DWT).

Step 3) Compute Project Cost Saving over the Project Life

[38] The following example was taken from Appendix B of IWR's Report 10-R-4 "Deep Draft Navigation National Economic Development Manual."

These are defined as the difference between the transportation cost with and without a project. The unit cost savings are then multiplied by the forecasted tonnages. The project savings for this particular vessel is $.68 per ton ($11.02 from step 1 less $10.34 from step 2). This will yield a benefit stream over time for each alternative and it is the analyst's job to then sum the savings for each times period of the project life to obtain the total benefits.

NED benefits were assessed for the alternatives in this reevaluation following the methodology prescribed by the Corps Planning Guidance Notebook for deep draft economic analysis (IWR 2010).

Benefits are equal to the difference between without (-36 MLLW) and with project transportation cost (-37 and -38 MLLW). All costs are adjusted to the base year of the project, 2017, and are then converted to Average Annual Equivalent (AAEQ) values using the Fiscal Year (FY) 2014 Federal discount rate of 3.5 percent, assuming a 50-year study period. All costs are at 3rd Quarter 2017 price levels. The benefits estimated for the separable elements of each alternative will be compared to its cost to determine its economic justification. The plan that maximizes net benefits (average annual benefits less average annual cost) is the NED Plan. The NED Plan is the Federal recommended plan, and, as is the case with Grays Harbor, equivalent to the locally preferred plan[39]. The annual cost for each alternative along with the corresponding benefit stream can be found in Table 21 below. Modeling was run on the base year (2017) and then at 10 year increments up to 2037 at which point the cost and benefits were held constant. Linear interpolation was used for the benefits and costs for the years that modeling was not run.

Using the steps above we find that for the Port of Grays Harbor in 2017 the Bulker 40k and Bulker 60k had the largest cost savings per ton at $2 respectively (Table 19 below). The total transportation cost savings for the Port of Grays Harbor for the base year of 2017 is approximately $8.4 million dollars. This same method would apply to subsequent years (2027 and 2037) to come up with a stream of benefits for each alternative found in Table 22 below.

[39] NED analysis generally analyzes a suite of alternatives but for Grays Harbor the analysis was constrained, at the request of the sponsor, to -37 and -38 MLLW. Thus the plan recommended, under the constraints, is the plan that maximized the net benefits and not necessarily what is traditionally thought of as the NED maximizing plan.

Table 19: Cost Per Ton by Vessel Class

2017 Cost Per Ton				
Metric	**VesselClass**	**36ft**	**38ft**	**Cost Savings**
Cost Per Ton	Bulker 30k	$ 26.00	$ 26.00	$ -
Cost Per Ton	Bulker 40k	$ 19.00	$ 17.00	$ 2.00
Cost Per Ton	Bulker 50k	$ 22.00	$ 21.00	$ 1.00
Cost Per Ton	Bulker 60k	$ 18.00	$ 16.00	$ 2.00
Cost Per Ton	Bulker 80k	$ 13.00	$ 12.00	$ 1.00
Cost Per Ton	Tanker-Small	$ 27.00	$ 26.00	$ 1.00
Cost Per Ton	Tanker-Medium	$ 20.00	$ 19.00	$ 1.00
Cost Per Ton	Ro-Ro 10k	$ 121.00	$ 120.00	$ 1.00
Cost Per Ton	Ro-Ro 20k	$ 73.00	$ 73.00	$ -

8.1.1 Annual Cost Savings

The resulting annual cost savings (benefits) were based on the difference between the without (Alternative 1: No Action) and the –with project (Alternative 2 (-37 feet MLLW) and Alternative 3 (-38 feet MLLW)) cost accrued throughout 50-year period of analysis. Table 20 displays the expected cost savings associated with the operation of each year from 2017 out to 2067 for alternative 2 and 3.

Table 20: Annual Transportation Cost and Transportation Cost Savings (Benefit) Stream

Annual Cost and Benefit Stream					
	Alt 1 (No Action)	Alt 2 (-37MLLW)		Alt 3 (-38MLLW)	
Year	Transit Cost	Transit Cost	Transit Benefit	Transit Cost	Transit Benefit
2017	**$ 134,794,705**	**$ 131,750,827**	**$ 3,043,878**	**$ 126,361,068**	**$ 8,433,637**
2018	$ 136,005,703	$ 132,731,187	$ 3,274,516	$ 127,708,759	$ 8,296,944
2019	$ 137,216,701	$ 133,711,547	$ 3,505,154	$ 129,056,450	$ 8,160,251
2020	$ 138,427,699	$ 134,691,907	$ 3,735,792	$ 130,404,140	$ 8,023,558
2021	$ 139,638,697	$ 135,672,267	$ 3,966,430	$ 131,751,831	$ 7,886,865
2022	$ 140,849,695	$ 136,652,627	$ 4,197,068	$ 133,099,522	$ 7,750,173
2023	$ 142,060,692	$ 137,632,986	$ 4,427,706	$ 134,447,213	$ 7,613,480
2024	$ 143,271,690	$ 138,613,346	$ 4,658,344	$ 135,794,904	$ 7,476,787
2025	$ 144,482,688	$ 139,593,706	$ 4,888,982	$ 137,142,594	$ 7,340,094
2026	$ 145,693,686	$ 140,574,066	$ 5,119,620	$ 138,490,285	$ 7,203,401
2027	**$ 146,904,684**	**$ 141,554,426**	**$ 5,350,258**	**$ 139,837,976**	**$ 7,066,708**
2028	$ 148,446,378	$ 143,343,692	$ 5,102,686	$ 141,420,615	$ 7,025,763
2029	$ 149,988,072	$ 145,132,957	$ 4,855,115	$ 143,003,254	$ 6,984,818
2030	$ 151,529,766	$ 146,922,223	$ 4,607,543	$ 144,585,894	$ 6,943,872
2031	$ 153,071,460	$ 148,711,489	$ 4,359,971	$ 146,168,533	$ 6,902,927
2032	$ 154,613,154	$ 150,500,755	$ 4,112,400	$ 147,751,172	$ 6,861,982
2033	$ 156,154,848	$ 152,290,020	$ 3,864,828	$ 149,333,811	$ 6,821,037
2034	$ 157,696,542	$ 154,079,286	$ 3,617,256	$ 150,916,450	$ 6,780,092
2035	$ 159,238,236	$ 155,868,552	$ 3,369,684	$ 152,499,090	$ 6,739,146
2036	$ 160,779,930	$ 157,657,817	$ 3,122,113	$ 154,081,729	$ 6,698,201
2037-2057	**$ 162,321,624**	**$ 159,447,083**	**$ 2,874,541**	**$ 155,664,368**	**$ 6,657,256**
Average Annual Benefits			**$ 3,661,000**		**$ 7,142,000**

These cost savings, found in table 20, were annualized and taken as a benefit for implementing a project. The outcome is displayed below in Figure 29 and Figure 30.

NED ANALSYSIS -37 MLLW	
Average Annual Benefits	$ 3,661,000
Average Annual Cost	$ 751,000
Net Benefits	$ 2,910,000
Benefit to Cost	4.9

Figure 29: NED Analysis -37 MLLW

NED ANALYSIS -38 MLLW	
Average Annual Benefits	$ 7,142,000
Average Annual Cost	$ 1,382,000
Net Benefits	$ 5,760,000
Benefit to Cost	5.2

Figure 30: NED Analysis -38 MLLW

9 Risk and Uncertainty

9.1.1 Risk-Informed Decision Making

The Risk-Informed Decision Making process described in previous sections provides a general framework that can be incorporated in various economic functions. The general requirement is to identify all assumptions, predicted variables, estimated values and parameter values that are critical to the report recommendation and the value of each critical factor where the recommendations would change or feasibility would be questioned. The specific analyses which are, or may be, required address assumptions such as to traffic projections, rates, vessel operating costs, vessel fleet composition or vessel fleet characteristics.

A risk analysis of the parameters influencing each alternative must be conducted to:

- Identify all critical parameters underlying the justification of each alternative
- Determine the range of conditions under which each alternative is justified.
- Identify potential risks, how it could occur, the likelihood of the risk and consequences

The analyst should distinguish between external and internal parameters. External parameters are those factors which occur independently of project implementation, for example, custom fees. Internal parameters are those factors directly related to project implementation, for example, commodity flows.

Specific areas that might be addressed in a risk analysis are:

- Uncertainty in commodity forecast

- Variation in fleet composition
- Sensitivity of transportation costs to fuel price fluctuations, or other factors
- Global warming impacts on sea levels (See EC 1165-2-211) (PDF Size:457 kb) such as dockside infrastructure, draft and sediment changes, and possibly demand changes
- Southeast Asia's growing and shifting economy
- Movements towards less foreign oil dependence
- Uncertainty in distribution of domestic shell oil via rail

The key assumptions are described in the section KEY ASSUMPTIONS and the model limitation are listed in the section MODEL LIMITATIONS. To facilitate the risk informed decision making process there were three sensitivity analyses' conducted. The no growth after the base year of 2017 was modeled followed by changing the FY14 discount rate to 7% on the existing analysis to see what, if any, changes in net benefits would occur. In addition, the scenario in which the CBR does not utilize Grays Harbor was modeled to ensure the project would be economically justified regardless of predicted commodity arrivals/flows. Results of the analysis are found in Section 10 below.

10 Sensitivity Analysis

Sensitivity analysis was conducted to help ensure that a risk informed decision was made by determining how changing an independent variable, such as growth rates, will impact a particular dependent variable (vessel operating cost) under a given set of assumptions. For this exercise the no growth after the 2012 existing conditions year was modeled followed by changing the FY14 discount rate to 7% on the existing analysis to see what, if any, changes in net benefits would occur. In addition, the scenario in which the CBR does not utilize Grays Harbor was modeled to ensure the project would be economically justified regardless of predicted commodity arrivals/flows.

10.1.1 No Growth After Base Year

To confirm the sensitivity of our commodity projections a no growth scenario was run. The initial run was based on the 2012 existing conditions year and the growth of the commodities entering the Port of Grays Harbor was held constant (zero growth). All commodities that are expected to call the Port of Grays Harbor in 2012 are included in the "no growth scenario". The findings confirm that the outcome is sensitive to the change in commodity tonnage but the results, with respect to which plan is the selected plan, did not change. In the no growth scenario alternative 3 (-38 MLLW) still maximized net benefits of the three alternatives considered and is a justified project using conservative numbers[40] (Figure 31: NED Analysis -38 MLLW (No Growth).

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[40] The 2012 cargo volume and vessels calls from January through July are approximately 1.9 million tons. The 2013 Port of Grays Harbor actual tonnage was 2.4 million metric tons.

NED ANALYSIS -38 MLLW (No Growth)	
Average Annual Benefits	$ 2,648,000
Average Annual Cost	$ 1,382,000
NED Benefits	$ 1,266,000
Benefit to Cost	1.92

Figure 31: NED Analysis -38 MLLW (No Growth)

10.1.2 Change in Discount Rate

The federal interest rate as prescribed by the U.S. Department of the Treasury, which computes it as the average market yield on interest-bearing marketable securities of the U.S. that have 15 or more years to maturity, changes throughout the years and more than likely will not be the same as assumed in the modeling. The interest rate that was used to derive the benefits and annualize the cost was the current FY14 discount rate of 3.5%.

Interest rates have an inverse relationship to present values. That is increases in expected interest rates result in lower present values because future values are discounted at a high rate to become smaller present values. The reciprocal is also true in that decreases in expected interest rates result in higher present values because future values are discounted at a lower rate.

To ensure an informed decision is made the interest rate used to determine the benefits and annualized the costs was changed from the 3.5% to 7%. This higher number would reduce the present values of future benefits and would give a better idea of what would happen if the cost to borrow capital were to increase. The benefit to cost ratios for both alternative 2 and 3, along with the average annual cost and benefits, changed under both scenarios. However, this change did not show a significant deviation from the previous results when using the FY14 3.5% discount rate. The plan that maximized the net benefits is still alternative 3 (-38 MLLW).

NED ANALSYSIS -37 MLLW (7% Discount Rate)	
Average Annual Benefits	$ 3,818,000
Average Annual Cost	$ 1,094,000
NED Benefits	$ 2,724,000
Benefit to Cost	3.5

Figure 32: NED Analysis -37 MLLW (7% Discount Rate)

NED ANALYSIS -38 MLLW (7% Discount Rate)		
Average Annual Benefits	$	7,351,000
Average Annual Cost	$	1,949,000
NED Benefits	$	5,402,000
Benefit to Cost		3.8

Figure 33: NED Analysis -38 MLLW (7% Discount Rate)

10.1.3 Elimination of CBR

Crude is expected to play a large role in the overall tonnage moved through the Port of Grays Harbor starting around 2015 and continuing throughout the 50-year analysis. One major concern is the validity of the economic analysis in the event that CBR does not utilize Grays Harbor due to factors that may include economic and/or external environmental considerations. Movement of crude by rail is a controversial issue in the Pacific Northwest and as such has faced opposition in the form of petitioners from the likes of the Quinault Indian Nation, Sierra Club, and Citizens for a Clean Harbor. In early October of 2013 the Washington State Shorelines Hearings Board (WSSHB) reversed the permits submitted by Westway Terminal Company and Imperium Terminal Services for terminal expansion for crude at Grays Harbor. The WSSHB requested that the City of Hoquiam and the Washington Department of Ecology conduct a complete review of the environmental risks and harms of an industrial crude zone. Although this has delayed the initiation of construction projects for the proposed new oil shipping terminals in Grays Harbor from an economic analysis standpoint it is still relatively likely to occur. However, if this were not the case and expansion of oil terminals is prohibited then in such a case we would expect to see a large reduction in the predicted tonnage moved through the Port. The major concern is that the benefits attributed to the reduction in transportation cost are derived from the reduction in the cost to move tonnage and as such the loss of CBR could change the outcome and final decision with respect to the deepening. To account for this concern analysis was done under the assumption that CBR does not utilize Grays Harbor and was not replaced by any other commodity, the results of which are displayed below in Figure 34 and Figure 35. With the elimination of CBR the plan with the greatest net benefits is Alternative 3 (-38 MLLW). Thus, the elimination of CBR does have an effect on the benefits but not so much that a change in the decision to select -38 MLLW as the NED plan is warranted.

NED ANALSYSIS -37 MLLW (No Crude)	
Average Annual Benefits	$ 1,830,000
Average Annual Cost	$ 751,000
Net Benefits	$ 1,079,000
Benefit to Cost	2.4

Figure 34: NED Analysis -37 MLLW (No Crude)

NED ANALYSIS -38 MLLW (No Crude)	
Average Annual Benefits	$ 3,571,000
Average Annual Cost	$ 1,382,000
Net Benefits	$ 2,189,000
Benefit to Cost	2.6

Figure 35: NED Analysis -38 MLLW (No Crude)

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Navigation Improvement Project
General Investigation Feasibility Study

FINAL Limited Reevaluation Report and Appendices

Appendix B: Engineering Analysis

Prepared by:
U.S. Army Corps of Engineers
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1. Physical Environment

The Grays Harbor Navigation Improvement Project (NIP) encompasses the Grays Harbor estuary from the cities of Westport to Aberdeen, Washington. Grays Harbor is located on the Southwest Washington coast, about 45 miles north of the Columbia River and 110 miles south of the entrance to the Strait of Juan de Fuca. A vicinity map including the federal navigation project features are shown in Figure 1. Grays Harbor is 15 miles long and 11 miles wide. The water surface area ranges from 91 square miles at mean higher high water (MWWH) to 38 square miles at mean lower low water (MLLW). The harbor broadens gradually from the river channel at the city of Aberdeen to a large, pear-shaped, shallow estuary encompassing North and South Bays. On the ocean side, two long spits enclose the estuary, Point Brown on the north and Point Chehalis on the south. Two convergent rubblemound-rock jetties, North Jetty and South Jetty, extend seaward from the sand spits at Point Chehalis and Point Brown, respectively; constricting the harbor entrance width to about 6,500 feet (Figure 1). A federally maintained navigation channel extends 27.5 miles from the outer Bar, through the Grays Harbor estuary, and terminating on the Chehalis River in Cosmopolis, WA. The navigation channel is classified between the outer harbor and inner harbor reaches. The outer harbor consists of the first 15 miles of channel and includes the Bar, Entrance, Point Chehalis, South, and Outer Crossover Reaches. The inner harbor consists of the remaining 12.5 miles of channel up to Cosmopolis, WA and consists of the Inner Crossover, North Channel, Hoquiam, Cow Point, Aberdeen, and South Aberdeen Reaches. Table 1 lists the channel stationing of each reach in the federal navigation channel.

1.1 Climatology

During late spring and summer, high-pressure centers predominate over the northeastern Pacific Ocean, sending a northwesterly flow of dry, warm air over the Chehalis Basin. The dry season extends from late spring to midsummer, with precipitation generally limited to a few light showers during this period. Average summer temperatures are in the 50’s and 60’s (°F), although hot, dry easterly winds that occasionally cross the Cascade Mountains can raise daytime temperatures into the 90’s. In fall and winter, strong winds and heavy precipitation occur throughout the basin. Storms are frequent and may continue for several days. Successive secondary fronts with variable rainfall may move onshore daily or more often. Heavy rainfall frequently is produced by these storms when warm, saturated air rises over the coastal range and west slopes of the Cascade Mountains.

Due to topographic controls, a variable weather pattern within the basin results in precipitation that ranges from an average of less than 45 inches per year near the city of Chehalis to an average of more than 200 inches per year in the upper reaches of tributary sub-basins draining the southern slopes of the Olympic Mountains.

1.2 Streamflow characteristics

The Chehalis, Humptulips, Wishkah, Elk, Johns, and Hoquiam Rivers are the major tributaries to Grays Harbor (Figure 2). The largest, the Chehalis River is approximately 125 miles long, originating in the Willapa and Doty hills southeast of Aberdeen and flowing northeast and then northwest before emptying into Grays Harbor. The Chehalis River enters at the head of the estuary and contributes approximately 80 percent of the freshwater discharge to the harbor. The Chehalis River drains 2,114 square miles into the inner harbor at Aberdeen, while the Humptulips River drains 276 square miles into North Bay. The smaller drainages include the Hoquiam River (98 sq. miles drainage area), Wishkah River (102 sq. miles drainage area), Elk River, Johns River, Newskah Creek, and Charlie Creek. South Bay has two estuaries at Elk River and Johns River, with six smaller, independent drainages (O'Leary, Stafford, Indian, Chapin, Newskah and Charley Creeks) entering Grays Harbor between Johns River and the mouth of the Chehalis River.

Table 1: Grays Harbor federal navigation project - channel reach and stationing

Channel reach	Authorized depth (feet, MLLW)	Channel Station	Within NIP
Bar Channel	-46	0+00 to 280+89	No
Entrance Channel	-44	280+89 to 342+89	No
Entrance Channel	-42	342+89 to 377+00	No
Pt. Chehalis Reach	-40	377+00 to 463+00	No
South Reach	**-38**	**463+00 to 715+93**	**Yes**
Outer Crossover Reach	**-38**	**715+93 to 795+00**	**Yes**
Inner Crossover Reach	**-38**	**795+00 to 869+00**	**Yes**
North Channel	**-38**	**869+00 to 1005+71**	**Yes**
Hoquiam Reach	**-38**	**1005+71 to 1156+02**	**Yes**
Cow Point Reach	**-38**	**1156+02 to 1227+99**	**Yes**
Aberdeen Reach	-36	1227+99 to 1315+86	No
South Aberdeen Reach	-36	1315+86 to 1448+04	No

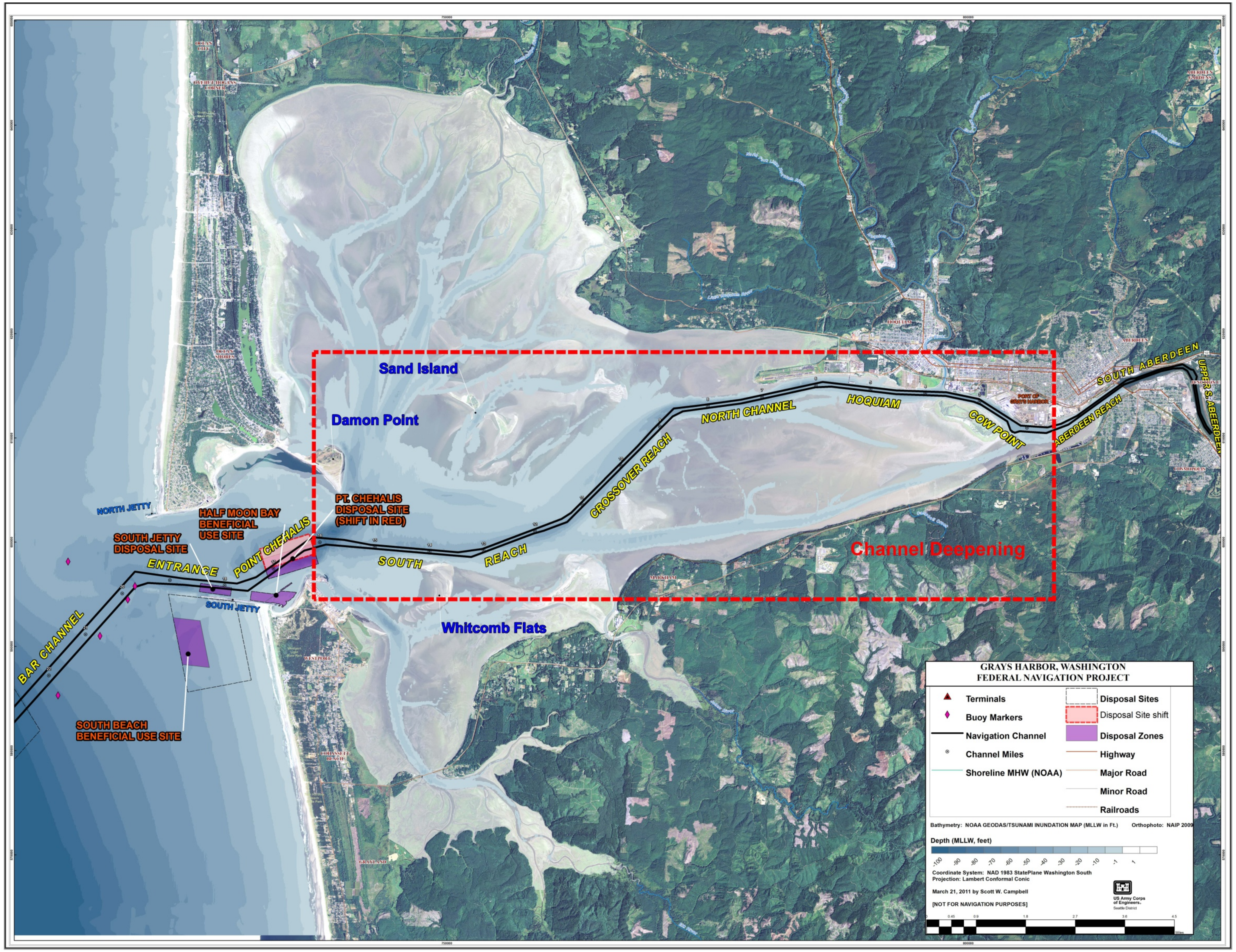

Figure 1: Grays Harbor Navigation Improvement Project and minor channel realignment

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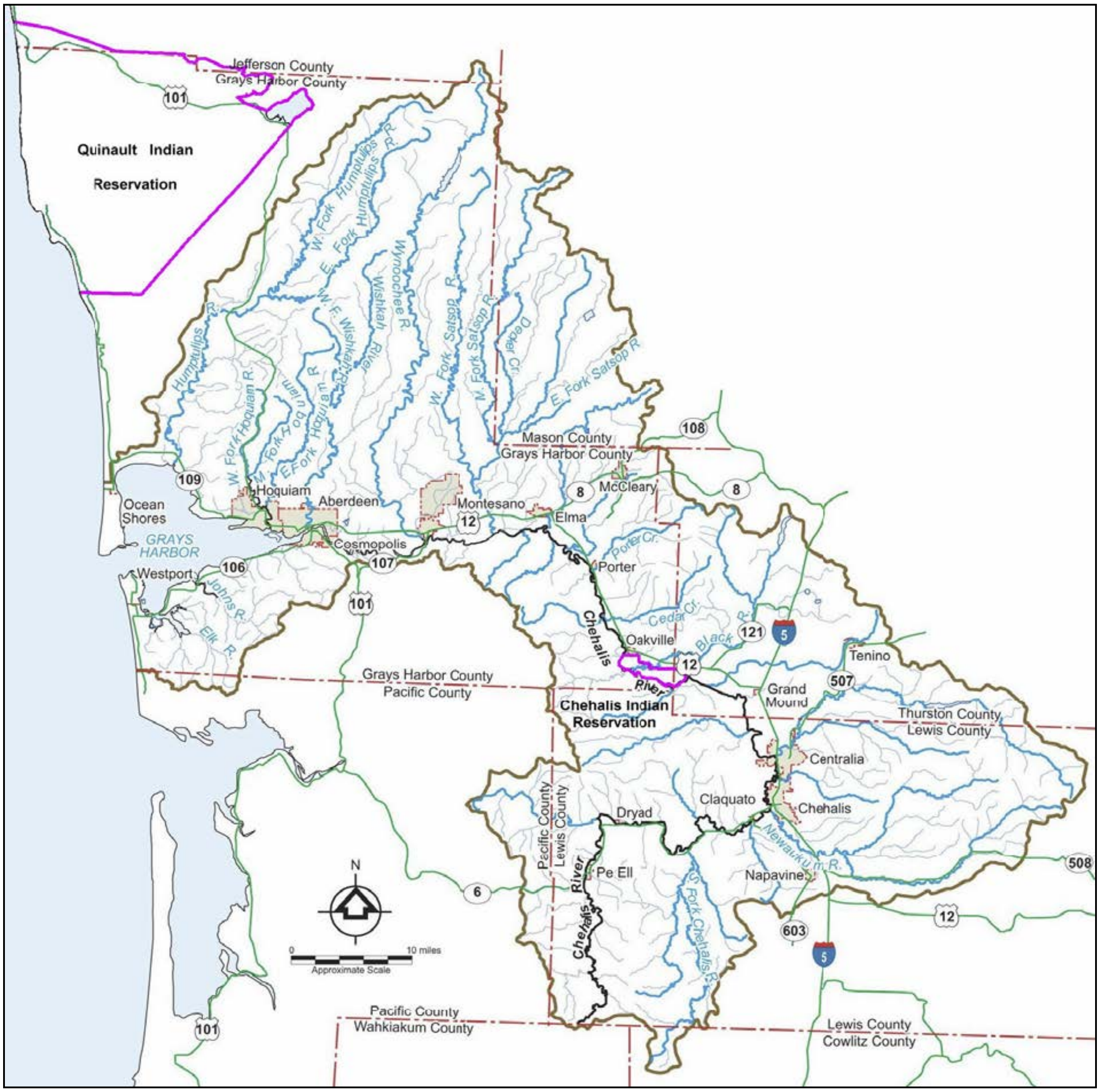

Figure 2: Chehalis River Basin tributaries (from Chehalis Basin Partnership)

1.3 Tides

Tides at in Grays Harbor have the diurnal inequality typical of the Pacific Coast of North America. Tidal datums for Westport and Aberdeen are listed in Table 2 and 3 respectively. The mean diurnal tidal range for Westport published by the National Ocean Survey is 9.15 feet. The mean diurnal tidal range for Aberdeen is 10.11 feet. The tidal phase lag at Aberdeen is approximately 1 hour later at high tide and low tide. Observed water levels are primarily a function of astronomical tide influences. However anomalies from the predicted astronomical tide occur due to factors including changes in atmospheric pressure, wind set-up, wave set-up, and river discharge.

1.4 Sea Level Change

Sea level change (SLC) is required to be considered in all USACE Civil Works projects per the guidance presented in EC 1165-2-212 (USACE 2011). The guidance states that "engineering designs should consider alternatives that are developed and assessed for the entire range of possible future rates of sea-level change". The guidelines require an active tide station with at least a 40 year record length to estimate sea level change for a project. Therefore data from NOAA tide station 9440910, Toke Point, WA was used for the analysis as data at the Westport gage has only been collected since 2006 and is of insufficient duration for developing accurate long-term sea level trends. The long-term trend line indicates an increase of 1.48 mm/yr (0.058 inches/yr) in local mean sea level. Table 4 lists the incremental (5-year) sea level change estimates calculated per the guidance for the next 100-years. The low, intermediate, and high represent different sea level rise scenarios. The low extrapolates the historic rate while the intermediate and high assume global sea level rise accelerates over time. By the end of the 50-year project lifecycle in 2065, local mean sea level is estimated to rise between 0.3 to 2.0 feet. In 100 years, local mean sea level at the project is estimated to rise between 0.5 to 5.9 feet.

1.5 Currents

Tidal currents dominate the current regime in the estuary; except during high Chehalis River flow. In general the strongest currents follow the channel thalweg1. Figure 3 and 4 display velocity magnitude (color contours) and direction (vectors) during four tidal stages (peak ebb, peak flood, low water slack, and high water slack) predicted by the CMS-FLOW two-dimensional hydrodynamic model during low flow conditions. During peak ebb flows, current speeds approach 4 knots (2 m/s) near the distal end of Damon Point. In the navigation channel at the Point Chehalis and South Reach currents are above 2 knots. Tidal currents generally diminish to less than 2 knots in the Crossover, North Channel, and Hoquiam Reaches. Near the Port of Grays Harbor terminals in the Cow Point reach these currents diminish to less than 1 knot. During peak flood, current speeds approach 3 knots (2 m/s) near the distal end of Damon Point and exceed 5 knots along the North Jetty. In the navigation channel, at the Point Chehalis and South Reach currents are above 2 knots. Tidal currents generally diminish to less than 1.5 knots in the Crossover, North Channel, and Hoquiam Reaches. Near the Port of Grays Harbor terminals in the Cow Point reach these currents diminish to less than 0.5 knots. During slack water conditions, currents throughout the navigation channel are primarily under 1 knot in the South Reach and under 0.5 knots upstream into the inner harbor reaches.

Table 2: Tidal datums at Westport, Washington, NOS Station 9441102

Datum	Water Level
Highest Observed Water Level (1 January 2010)	12.67
Mean Higher-High Water (MHHW)	9.15
Mean High Water (MHW)	8.41

[1] Thalweg. The line defining the lowest points along the length of a river bed or valley

Mean Tide Level (MTL)	4.90
Mean Low Water (MLW)	1.39
North American Vertical Datum (NAVD)	1.19
Mean Lower Low Water (MLLW)	0
Lowest Observed Water Level (7 May 2008)	-3.55

Table 3: Tidal Datums at Aberdeen, Washington, NOS Station 9441187

Datum	Water Level
Highest Observed Water Level (3 December 1982)	13.86
Mean Higher-High Water (MHHW)	10.11
Mean High Water (MHW)	9.41
Mean Tide Level (MTL)	5.44
North American Vertical Datum (NAVD)	1.64
Mean Low Water (MLW)	1.47
Mean Lower Low Water (MLLW)	0
Lowest Observed Water Level (22 July 1982)	-3.35

Table 4: Sea-level change scenarios (in feet) at Toke Point, Washington per EC 1165-2-212

Year	Low	Intermediate	High
2015	**0.00**	**0.00**	**0.00**
2020	0.02	0.05	0.12
2025	0.05	0.10	0.26
2030	0.07	0.15	0.41
2035	0.10	0.21	0.59
2040	0.12	0.28	0.78
2045	0.15	0.35	0.99
2050	0.17	0.42	1.22
2055	0.19	0.50	1.47
2060	0.22	0.58	1.74
2065	**0.24**	**0.67**	**2.02**
2070	0.27	0.76	2.33
2075	0.29	0.86	2.65
2080	0.32	0.96	2.99
2085	0.34	1.06	3.35
2090	0.36	1.17	3.73
2095	0.39	1.28	4.13
2100	0.41	1.40	4.54
2105	0.44	1.53	4.97
2110	0.46	1.65	5.43
2115	**0.49**	**1.78**	**5.90**

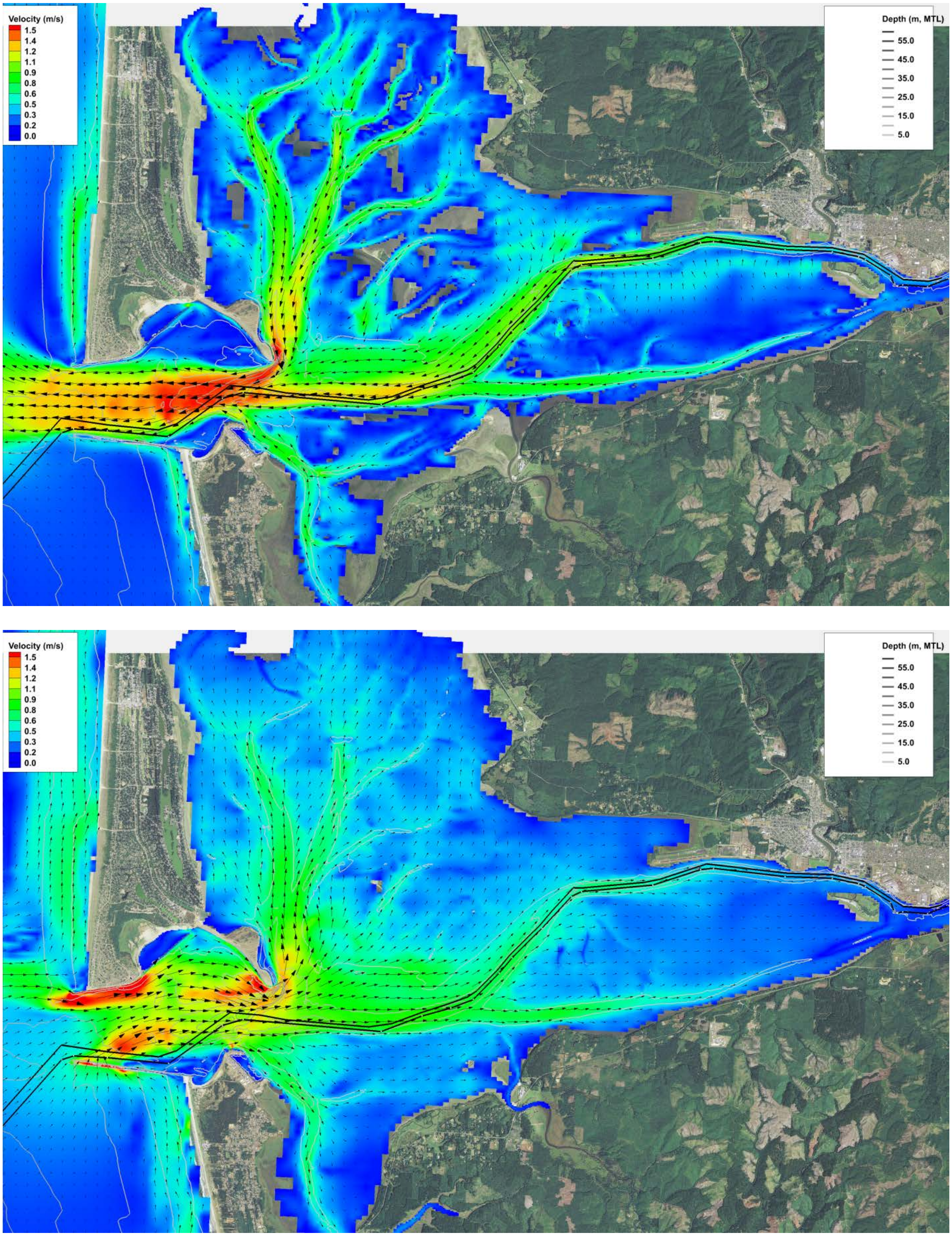

Figure 3: Peak ebb (top) and peak flood (bottom)

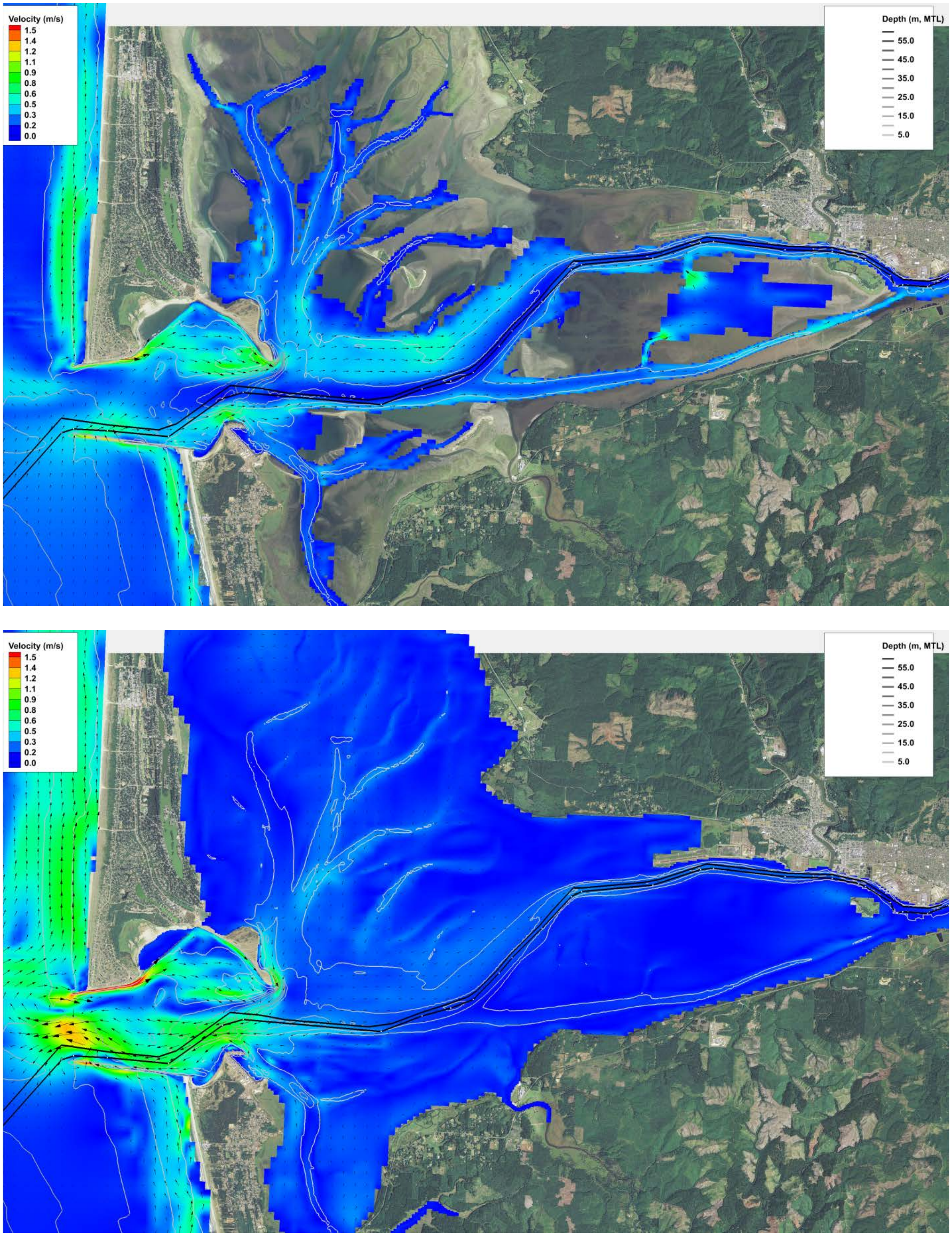

Figure 4: Low water slack (top); high water slack (bottom)

1.6 Winds

The seasonal cycle of winds over the northeast Pacific Ocean is largely determined by the circulation about the North Pacific high pressure area and the Aleutian low pressure area which drives the jet stream over the North Pacific. During the summer months, the high reaches its greatest development. In July the center of highest pressure is located near latitude 35° N., longitude 150° W. During this period, the Aleutian low is almost nonexistent. This pressure distribution causes predominantly northwest and north winds over the coastal and near offshore areas of Oregon and Washington. The high weakens with the approach of the winter season and by November is usually little more than a weak belt of high pressure lying between the Aleutian low and the equatorial belt of low pressure. These traveling depressions moving eastward cause considerable day-to-day variation in pressure, particularly in the area north of latitude 40° N.

As shown in Figure 5, at Westport the prevailing wind direction is out of the northwest. The strongest winds originate from the northwest and southerly directions and have recorded 2 minute average wind speeds exceeding 54 miles per hour. As shown in Figure 6 at Hoquiam, the prevailing wind directions are east and west as a result of the direction of the greatest fetch distances through the harbor.

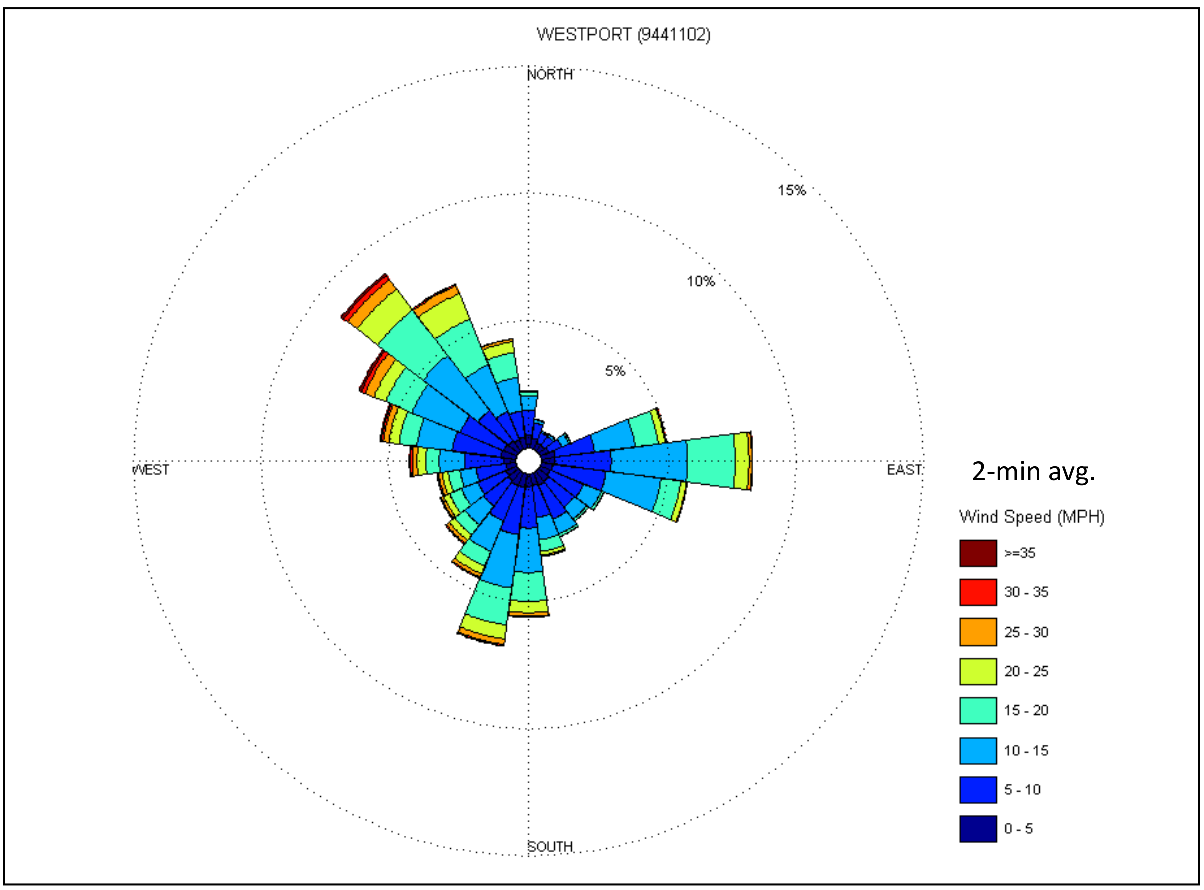

Figure 5: Wind rose at NOAA CO-OPS Station 9441102 Westport, WA. 2008-2013 (6 years)

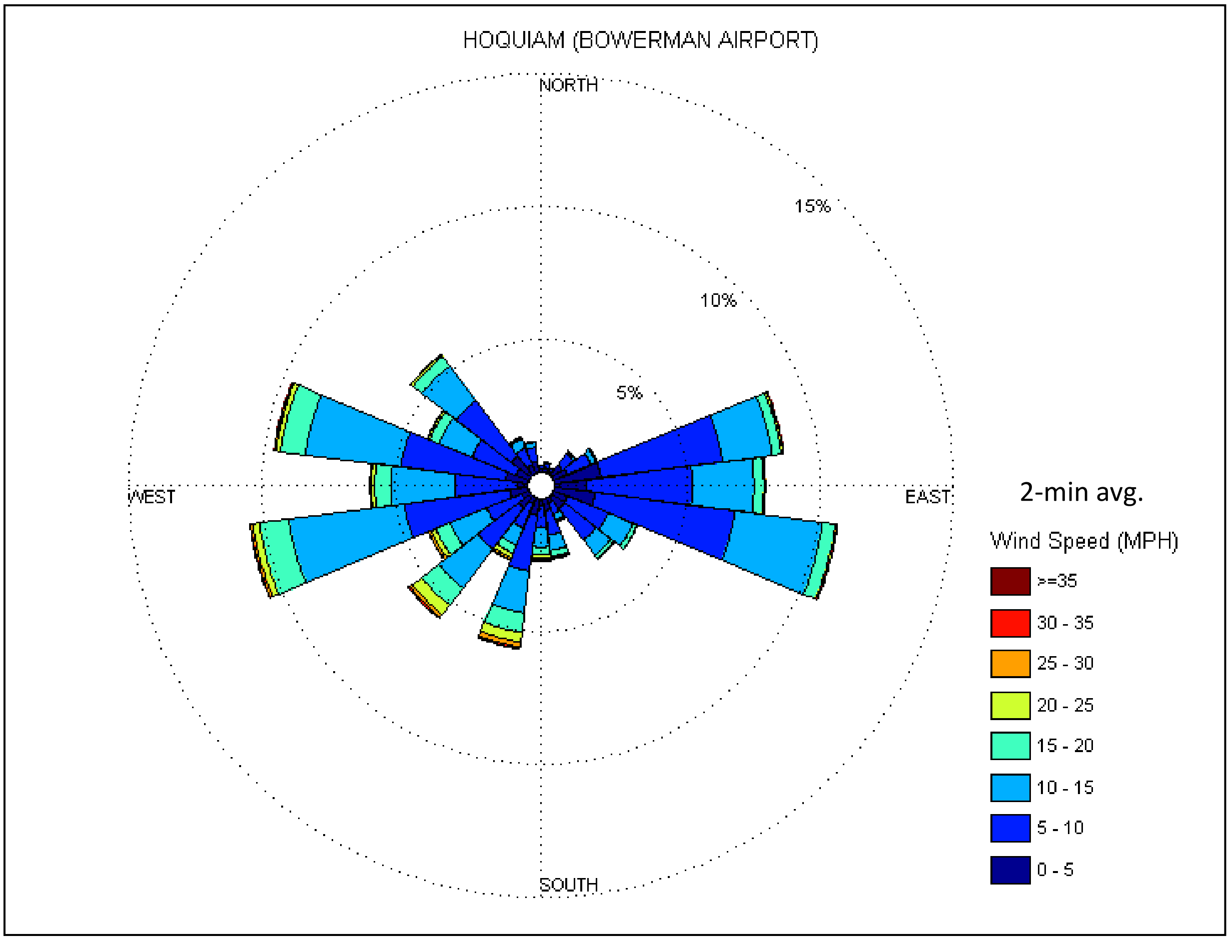

Figure 6: Wind rose at Bowerman Airport in Hoquiam, WA. 1949-1959; 1973-1990 (29 years)

1.7 Waves

Wave data has been observed at the Coastal Data Information Program (CDIP) buoy offshore of Grays Harbor in 130 feet of water since 1981. The average annual significant wave height measured at the buoy is 7 feet (2.1 meters) with a period of 11 seconds. The primary wave direction varies seasonally. The prevailing waves in the milder summer months are from the northwest. While large storms generated in the winter months have a southwesterly directionality. Weather fronts associated with maritime cyclonic storms in the Northeast Pacific can extend over the ocean for 1,000 miles and cover a latitude difference of 25 degrees. When these maritime low-pressure systems make land fall on the coast they produce hurricane-like conditions. Sustained wind speeds can be greater than 40 knots for fetches greater than 125 miles. The resulting wind stress can produce ocean waves greater than 30 feet high and a "set-up" of the mean water level of 1 to 5 feet, depending on storm evolution. An extreme wave height distribution is plotted in Figure 7. The 50-year recurrence interval (or 2% annual exceedance probability) is 37.4 feet.

As ocean swell and locally generated seas propagate into the inlet the processes of wave shoaling, refraction, diffraction, and reflection transform the waves. Wave transformation into

Grays Harbor has been investigated using the Coastal Modeling System –WAVE model (Li et al. 2013). Figure 8 and 9 plot significant wave height for three wave directions (southwest, west, and northwest). These results indicate most of the wave energy refract to toward the north and south shorelines towards shallow water as they enter the mouth. In general waves from the northwest focus more energy on Point Chehalis while waves from the west and southwest focus wave energy on the North Jetty and Damon Point.

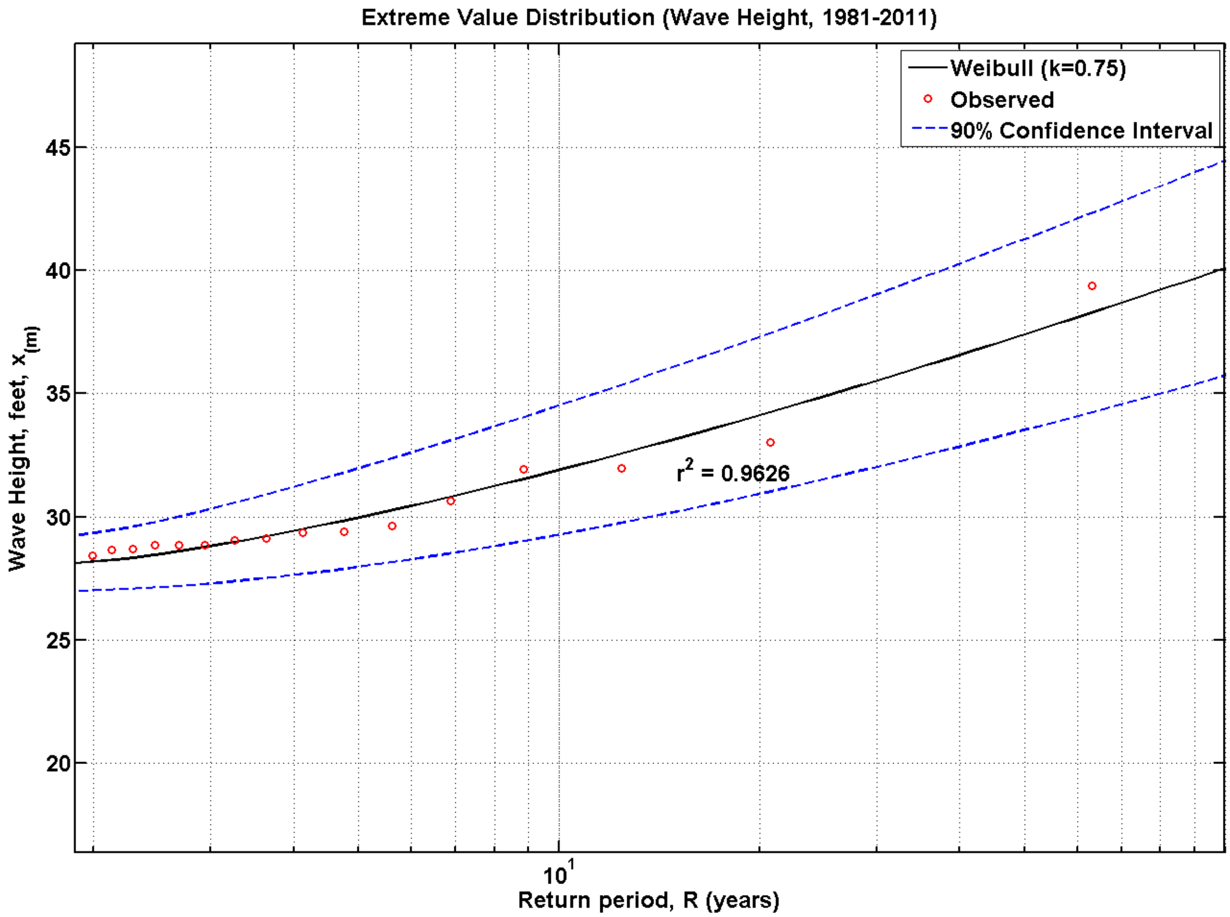

Figure 7: Extreme value distribution of significant wave heights from CDIP buoy 036 Grays harbor, WA (46.857N 124.244W) for 1981-2011.

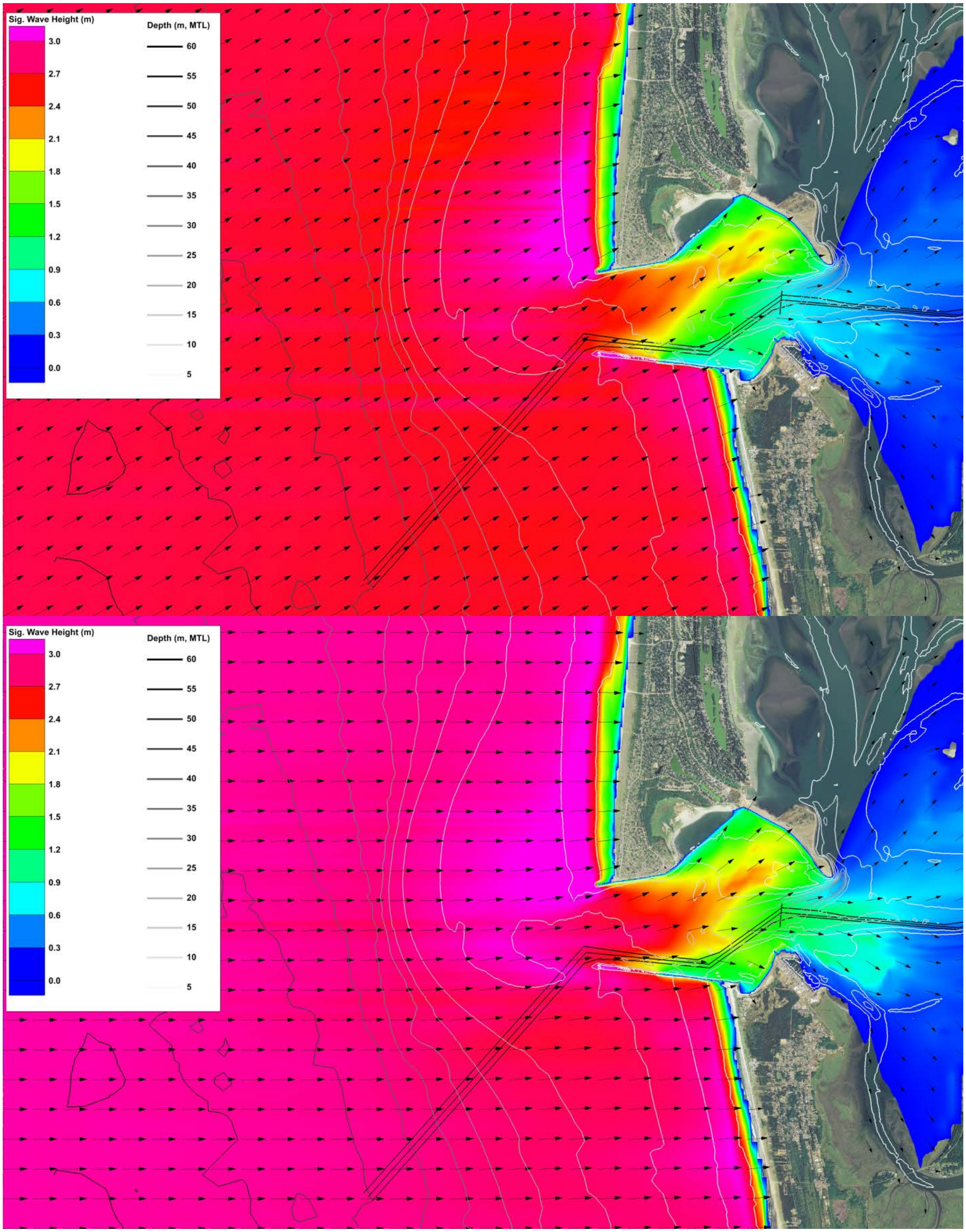

Figure 8: CMS-WAVE computed significant wave height (Hs) with a Southwest (top) and West (bottom) incident wave direction for peak wave period (Tp) = 12.5 sec.

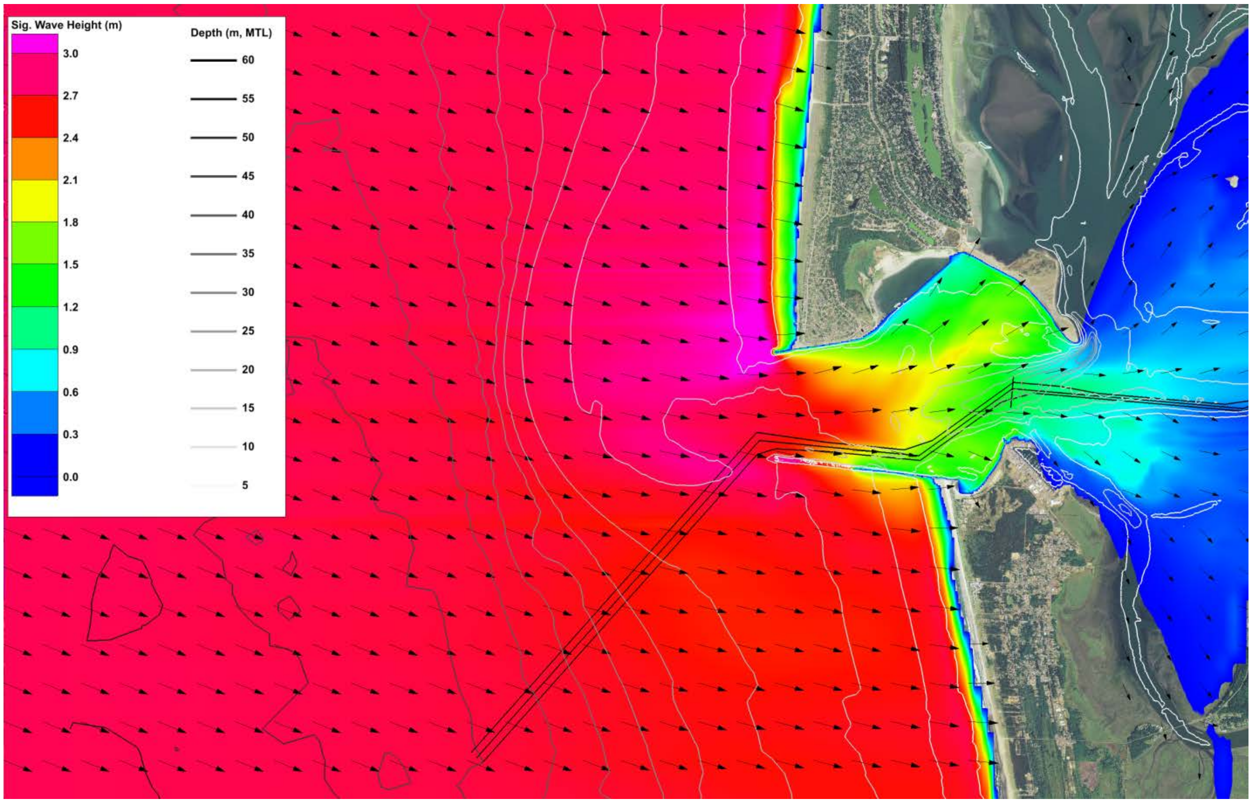

Figure 9: CMS-WAVE computed significant wave height (Hs) with a Northwest (top) incident wave direction for peak wave period (Tp) = 12.5 sec.

Ocean swells from the west and northwest generally result in more energy entering the inner harbor than from the southwest. Model results indicate the significant wave height is reduced to less than 2 feet (0.63 m) in the middle of the South Reach (Figure 10). Ocean swell is dissipated even more in the outer cross-over reach and is negligible at the inner cross-over through the remaining inner harbor channel reaches. The inner harbor reaches are also exposed to locally generated wind waves. Fetch lengths are largest during high tide and can produce waves on the order of 1 to 3 feet. Wind generated waves have shorter periods than ocean swell and seas and typically range from 2 to 4 seconds. These waves are capable of transporting fine grained materials within the inner harbor.

Vessel generated waves also occur in the inner harbor channel reaches. The waves are created by recreational craft, commercial fishing boats, barge and tugs, and deep draft ships. Vessel generated waves typically are short in wave period and typically only impact shallow regions close in proximity to the sailing line. Downstream of North Reach vessel generated waves have minimal effect on shallow areas as these as distances exceed 1500 feet from the sailing line. Shorelines adjacent to the North, Hoquiam, and Cow Point reaches may experience vessels wakes on the order of 1 to 3 feet. It is not expected the wave height will increase with future vessel traffic as the design vessel has not changed, however the frequency of the wakes may increase. However, most of the shoreline is already armored with slope protection thus additional bank erosion associated with the additional vessel traffic is not anticipated.

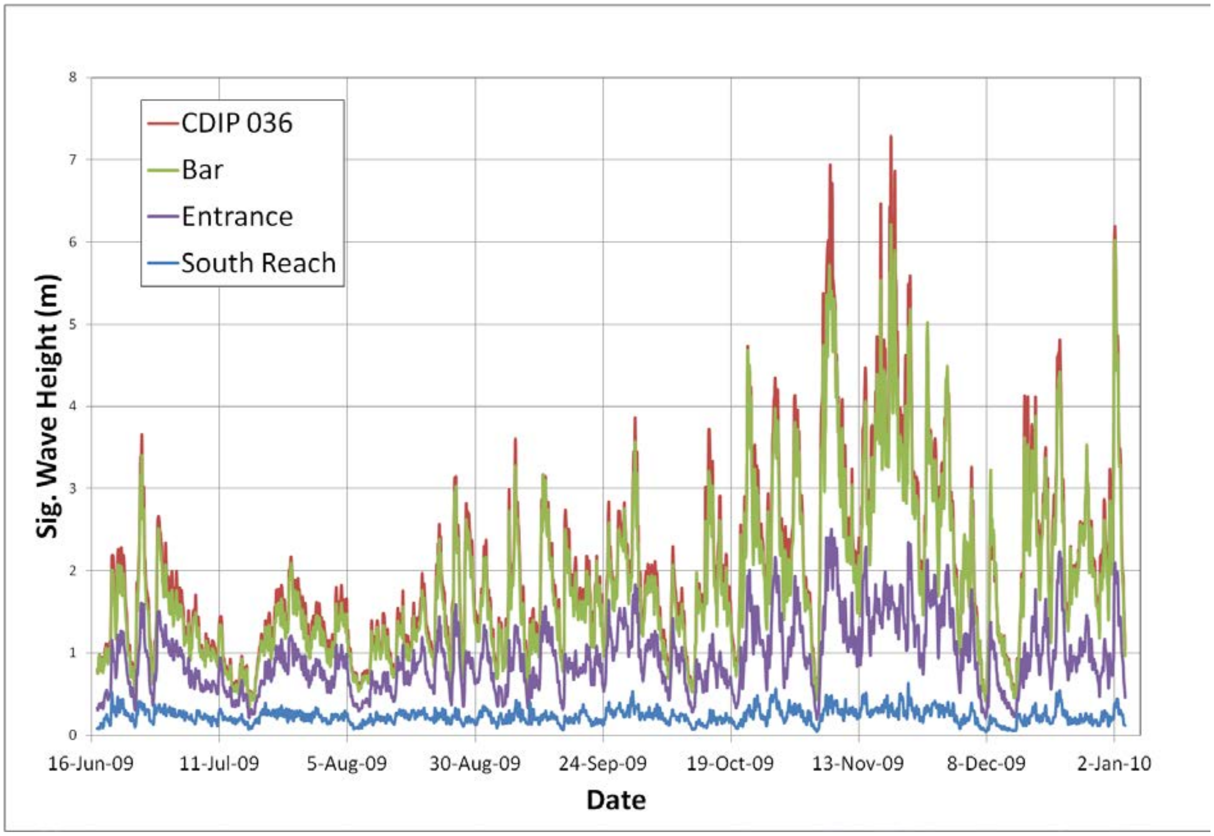

Figure 10. Significant wave height (in deepwater at CDIP 036, in Bar Channel) at mouth of harbor; in Entrance Channel inside harbor; in middle of South Reach.

2. Project History

2.1. Pre Project Condition

Like other coastal ports on the Pacific Ocean, drifting sand bars obstructed safe entrance into Grays Harbor. Only three passages existed in the early 1880s, the deepest offering transit to vessels of 21 feet draft. The need to support the booming timber industry in the Grays Harbor region sparked the Corps of Engineers to assist with engineering the inlet. Below is the description of the harbor in the 1882 Annual report of the Chief of Engineers:

> The Chehalis River becomes the eastern portion of Grays Harbor. From here two channels, one to the north and the other to the south, reach through shoals for a dozen miles toward the sea. Although broadening in its western extremity, much of the harbor is exposed at the lowest extent of tide. Grays Harbor, noted Hiram Chittenden Seattle District Engineer. "Is really a vast mud flat"...The problem at the entrance to the harbor was that the channel underwent constant and confusing relocation; it shifted to the south by an estimated thousand feet between 1862 and 1881 alone. In some seasons it was straight, in others crooked, and at all times the depth varied by several feet. Mariners had to have their sailing vessels towed to sea and could be barbound for weeks due to adverse winds and tide.

As indicated in the 1890 survey on Figure 11, the thalweg through the inner harbor to Hoquiam follows a similar alignment as the present day navigation channel. The depths in the thalweg ranged from 10 to 40 feet. However the depths through the harbor mouth varied drastically ranging from 0 feet to greater than 100 feet.

2.2. Engineering activities for navigation

Table 5 presents a chronology of major engineering activities undertaken in the construction and maintenance of the Federal Navigation Project in Grays Harbor.

South Jetty construction (1898-1902)

In order to provide a reliable channel of suitable depth a single rock jetty was proposed on the southern side of the harbor. Similar jetties at the Mouth of the Columbia and Coos Bay federal navigation projects had been undertaken by the Corps of Engineers Portland District using a timber supported railroad trestle system. The same proven methodology was utilized to construct the South Jetty at Grays Harbor. Here the trestle used to construct the South Jetty was built a distance of 10,000 feet from the oceans high water line. Rock ranging from 50 to 2000 pounds was dumped from the trestle onto a 3 foot thick woven brush mattress foundation. The brush mattress was utilized to prevent excessive erosion of sand along the line of the trestle as tidal currents were confined. This thereby reduced the quantity of stone required to secure the necessary elevation of the jetty. During the construction two channels with depths of 18 and 24 feet were crossed by the line of the jetty. Following construction of the jetties through these channels, the channels were immediately filled in with sand following the first winter season. Additionally to prevent erosion on the south of the jetty a 500 foot long groin was built at a point 11,000 feet west of the high water line (ARCE 1909; ARCE 1915). Figure 12 shows the condition of the harbor in 1909 following construction of the South Jetty. It can be seen that no clear channel across the bar was available to navigation. This led to the recommendation to the Chief of Engineers to undertake construction of a second jetty on the north side of the inlet based on the lessons learned from the construction of two-jettied systems built at the Mouth of the Columbia River and Coos Bay.

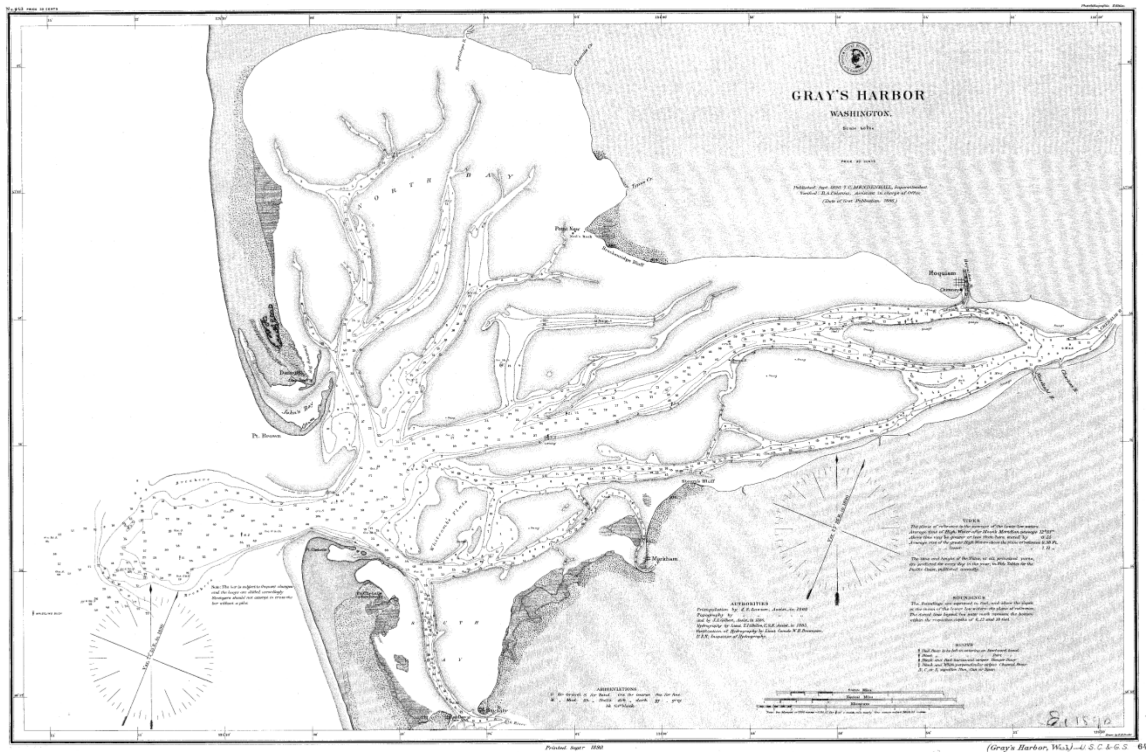

Figure 11. Grays Harbor configuration in 1890, prior to federal navigation project.

North Jetty construction (1907-1916)

The original project for the improvement of the entrance to Grays Harbor contemplated securing depths of 24 feet at mean lower low water by the construction of one jetty on the south side of the harbor entrance. However these depths were only secured for a short periods and were not permanent due to the shifting nature of sands to the north of the entrance. During the latter part of 1906 the Bar channel had seriously deteriorated without a reliable channel across the ebb shoal as indicated in Figure 12. As a result the project authorization was modified to include construction of a second jetty approximately 9,000 feet long on the north side of the entrance. The inner 7,000 feet of jetty were constructed from 1907-1910. At this time it was clear that the jetty needed to be extended to meet its intended function. In 1910 Congress authorized a 7,000 foot extension of the jetty. By 1913 the North Jetty was constructed to its fully authorized length. The period from 1913 to 1916 involved continuous repairs of the North Jetty to mean high water. The morphological feedback of the shoals and channels at the entrance during jetty construction highlight the fact that initial designs of the jetty configuration required adaptive management during construction to meet the intended project purpose. Figure 13 shows the condition of the project in 1916 following completion of the North Jetty.

Outer harbor channel improvement (1916 to 1942)

Construction of the north and south jetties were authorized to provide a 500 foot wide and 24 feet deep channel across the Bar. The 1916 condition survey indicated project depth of 24 feet was achieved. From 1916 to 1922 dredging of the Bar was performed intermittently but could not hold a consistent depth of 24 feet. In the summer of 1924 was the first time a dredge was available for an entire work season from June to October; a total of 652,781 cubic yards were dredged and on completion a channel 32 feet deep was secured across the bar (H. Doc No. 582, 69th Cong). However surveys in the following months indicated the Bar continued to shoal heavily with controlling depths varying from 22.5 to 26 feet. In 1925, dredging removed approximately 1.1 million cubic yards securing a Bar channel depth of 36 feet but surveys in the following winter indicated shoaling depths up to 25 feet. From 1928 to 1932 the minimum depth maintained over the Bar generally exceeded 28 feet. Between 1916 and 1942, dredging of the outer bar amounted to about 22 million cubic yards (USACE 1974).

Inner Harbor channel improvement (1905-1934)

The River and Harbor Act of June 13, 1902 provided continued authority for improvement of the inner harbor portion between the Bar and Aberdeen. In 1905, a channel 100 feet wide and 15 feet deep at low water was obtained by dredging through the shoal between Hoquiam and Aberdeen (Hoquiam Reach).

The River and Harbor Act of March 2, 1907 provided a channel 200 feet wide and 18 feet at mean lower low water from Cosmopolis (South Aberdeen Reach) to deep water below Hoquiam (Hoquiam Reach) a distance of about 15 miles; and a 6 feet and 150 feet wide channel between Cosmopolis and Montesano, Washington. This construction was completed in 1910 and required approximately 1.8 million cubic yards of dredging. The maximum draft that could be carried in 1910 over the shoals below Aberdeen at mean lower low water was 18 feet. (H. Doc. No. 53, 73rd Cong.).

In 1919 the Port of Grays Harbor Commission agreed to undertake maintenance dredging of the inner harbor reaches to a depth commensurate with that obtained on the outer bar; this dredging amounted to approximately 6.2 million cubic yards in 1919. Under this agreement the Port deepened 8.5 miles of the inner harbor to 26 feet over a channel width ranging from 200 to 350 feet. The natural depths from Aberdeen to Cosmopolis were nearly 26 feet thus no maintenance dredging was required to these channel reaches (H. Doc. No. 53, 73rd Cong.).
The River and Harbor Act of July 3, 1930 provided a 150 foot wide 16 feet deep channel from Cosmopolis to Montesano, a distance of 10.75 miles subject to the condition that local interests pay half the initial cost and assume the maintenance (H. Doc No 315, 70th Cong.). In 1931 a

channel 12 feet deep and 100 to 150 was constructed. Soon after, dredging this channel reach became classified as inactive.

In 1932, the Port of Grays Harbor was financially unable to continue maintenance dredging of the channel through the inner harbor to Aberdeen. The Board of Engineers for Rivers and Harbors and Chief of Engineers recommended the Corps take over maintenance dredging responsibilities in the inner harbor in order to secure the federal investments already made at the Bar (H. Doc. No. 53, 73rd Cong.).

South Jetty reconstruction (1935-1939)

From 1904 to 1933, the South Jetty subsided to elevations varying from +6 feet MLLW, on the shore end, to -10 feet MLLW at the seaward end. Between 1935 and 1939, 12,656 feet of the South Jetty was reconstructed to an elevation of +20 feet MLLW.

North Jetty reconstruction (1941-1942)

From 1941 to 1942 an 8,828 foot section between the seaward end and the high water line was reconstructed to +20 feet MLLW. Sediment transport over the jetty created shoaling within the harbor and progressively forced the Bar channel to migrate south toward the South Jetty. This resulted in considerable scour forces along the channel side of the South Jetty. After the North Jetty crest height was restored shoreline accretion from 1942 to 1959 north of the North Jetty on North Beach amounted to approximately 2 million cubic yards per year (USACE 1975).

Point Chehalis and Westhaven Cove construction (1950-1957)

The Port of Grays Harbor constructed a harbor at Westhaven Cove on Point Chehalis in 1929. The Cove which had been formed naturally a few years earlier was enlarged by dredging. Reconstruction of the South Jetty between 1935 and 1939 was a contributory cause of erosion of Point Chehalis by its effect upon wave and current action in the vicinity of the Point. Seven groins, three timber pile breakwaters, and a 2,880-foot rock revetment along the north and west shoreline were constructed from 1950 to 1957 to stabilize the shoreline and secure the boat basin in Westhaven Cove.

Inner Harbor Channel Improvement (1954)

In 1954 the following modifications (H. Doc. No. 412, 83rd Cong) were made to the navigation project:

- Provide a 30 feet deep and 350 feet wide channel from the Port of Grays Harbor Terminal 1 upstream to Cow Point (e.g. Cow Point Reach).
- Provide a 30 feet deep and 200 foot wide channel to Aberdeen, approximately 13,700 feet upstream of the Union Pacific Railroad Bridge (e.g. Aberdeen and South Aberdeen Reaches).
- Provide a turning basin 550 feet wide at Cosmopolis (e.g. Elliott Slough Turning Basin).

South Jetty rehabilitation (1966)

Between 1939 and 1962, the outer 4,400 feet of the jetty was destroyed leaving less than 5,000 feet of the jetty near grade (USACE 1965). In 1966, approximately 600,000 tons of new rock was placed to rehabilitate 4,000 feet of destroyed jetty (Sta. 110+00 to 150+00). Due to the excessive scouring forces on the channel side of the jetty the structures alignment was shifted approximately 35 feet south at the shoreward end and 133 feet south on the seaward end. Following rehabilitation, this left approximately 7,000 feet of the original jetty 1902 in a destroyed condition.

North Jetty rehabilitation (1976)

In the 1941-1942 reconstruction the remainder of the North Jetty landward of the high water line was not restored. Additionally by 1961 only 2,100 feet of the 1941-1942 reconstructed section was at or near grade. Similar to the prior rehabilitation significant littoral transport from north to south over the North Jetty was beginning to create impacts to O&M dredging of the navigation channel. Thus in 1976, approximately 200,000 tons of new rock was placed to rehabilitate the outer 6,000 feet of the jetty (Sta. 100+00 to 160+00).

South Reach (Sand Island) Channel Realignment (1976)

As the North Jetty deteriorated from 1942 to 1975 sediment entered the harbor from North Beach and resulted in increased shoaling rates in the navigation channel as well as the growth of the spit at Damon Point. This resulted in accretion in the Sand Island Reach of the navigation channel which historically followed the thalweg into the inner harbor adjacent to Sand Island. In effort to minimize adverse impacts to annual maintenance dredging costs, the Corps conducted a 4.5 mile channel realignment which shifted the navigation approximately 1 mile south of the former Sand Island Reach alignment (Figure 17). The initial volume to dredge the new South Reach channel to its authorized depth of -30 feet MLLW was approximately 3 million cubic yards (USACE 1976).

Navigation Improvement Project (1990-1991)

The 1990 channel deepening and widening began in April 1990 and concluded in February 1991. The project was completed using three separate contracts. Manson Construction Company and Great Lakes Dredge & Dock were awarded the contracts which dredged approximately 8.2 million cubic yards of sediment from the navigation channel from the Bar to Cow Point (USACE 1989; USACE 1990). The first contract was awarded to Manson for Outer harbor dredging of the Bar, Entrance, and South Reach using the Newport and Westport hydraulic hopper dredges. The second contract was awarded to Manson for dredging of the Crossover and North Channel with the Newport hopper dredge. The construction period of the first two contracts was from early May 1990 to February 1991. The third contract was awarded to Great Lakes Dredge & Dock and consisted of clamshell dredging of North Channel and Cow Point Reaches and hydraulic pipeline dredging of Cow Point Reach. Upland placement of sediment from the Cow Point Reach was performed with a pipeline dredge. The period of construction of this contract ranged from June to September 1990.

There were a few of changes from the recommended plan presented in the General Design Memorandum (USACE 1989) to what was eventually implemented during construction which was primarily due to the declining timber industry in the early 1990s. The primary deviations being, (1) The channel deepening of the Aberdeen Reach to -36 feet MLLW went only to an upstream Station of 1252+00. (2) The South Aberdeen Reach was not deepened to -36 feet MLLW. The South Aberdeen Reach was most recently dredged to a project depth of -32 feet MLLW in 1999. (3) The Elliott Slough Turning Basin was never widened to 750 foot width and still maintains a 550-foot width. (4) The recommended bridge modifications to the Union Pacific Railroad Bridge were never implemented and were later removed from the project.

Breach Fill (1994)

From 1954 to 1999, South Beach (the nearshore area south of the South Jetty) experienced a cumulative erosion or nearly 72.3 million cubic yards (Buijsman et al. 2003). Additionally, erosion in Half Moon Bay caused the shoreline to continue to recede. In December 1993, the beach and dune adjacent to the South Jetty become low and narrow enough that during a winter storm in a breach channel formed connecting the Pacific Ocean to Half Moon Bay. The channel widened and deepened over the course of the winter and was eventually filled with 600,000 cubic yards of dredged material in August 1994.

Point Chehalis Revetment Extension (1998-1999)

In June 1997, the Corps completed an Evaluation Report (USACE 1997) that recommended construction of a jetty extension to minimize the probability of a breach and the potential consequences to navigation. The planned solution consisted of:

- Extending the South Jetty eastward 4,300 feet. The first phase would include a 1,000 foot extension to the existing South Jetty alignment (Segment 1) and a 2,300 foot extension to the Point Chehalis revetment (Segment 2). The second phase would connect Segment 1 and 2 at project year 25 with a remaining 1,000 foot section of jetty.
- Beach nourishment for toe protection of the jetty extension at four-year intervals.

The Point Chehalis revetment was extended by 1,900 feet during the period November 1998 to March 1999. However, the South Jetty extension was never implemented. As a mitigation agreement with the resource agencies, nearshore placement of dredged material within the Half Moon Bay Beneficial Use Site is required to maintain a stable beach slope (1 vertical on 60 horizontal slope) within Half Moon Bay (USACE 1998).

South Jetty rehabilitation (1999-2002)

The steepening of the South Beach nearshore area resulted in larger waves attacking the South Jetty which resulted in more damages along the structure. By 1999 blowouts in the jetty crest allowed wave transmission and tidal currents through the jetty and threatened the reliability of navigation into the harbor. Thus in 1999 to 2002, the landward 3,300 feet (Sta. 87+00 to 110+00) of the South Jetty was rehabilitated (USACE 1999).

North Jetty rehabilitation (2000-2001)

From 1976 to 1996 the seaward reach of the jetty had lowered to +14 feet MLLW. Overtopping waves created large amounts of water to be deposited on the north side of the jetty root which formed two swash channels on the east and west end of the peninsula the North Jetty is attached. Drainage through and adjacent to the jetty became inadequate to convey this volume of water and threatened the stability of the jetty. From 2000 to 2001, 5,000 feet of the North Jetty were rehabilitated to +23 feet MLLW (Sta. 95+00 to 145+00). A 30 foot rock blanket (splash apron) was constructed to the north of the jetty crest to prevent scour along the north of the jetty from the swash channel (USACE 2000).

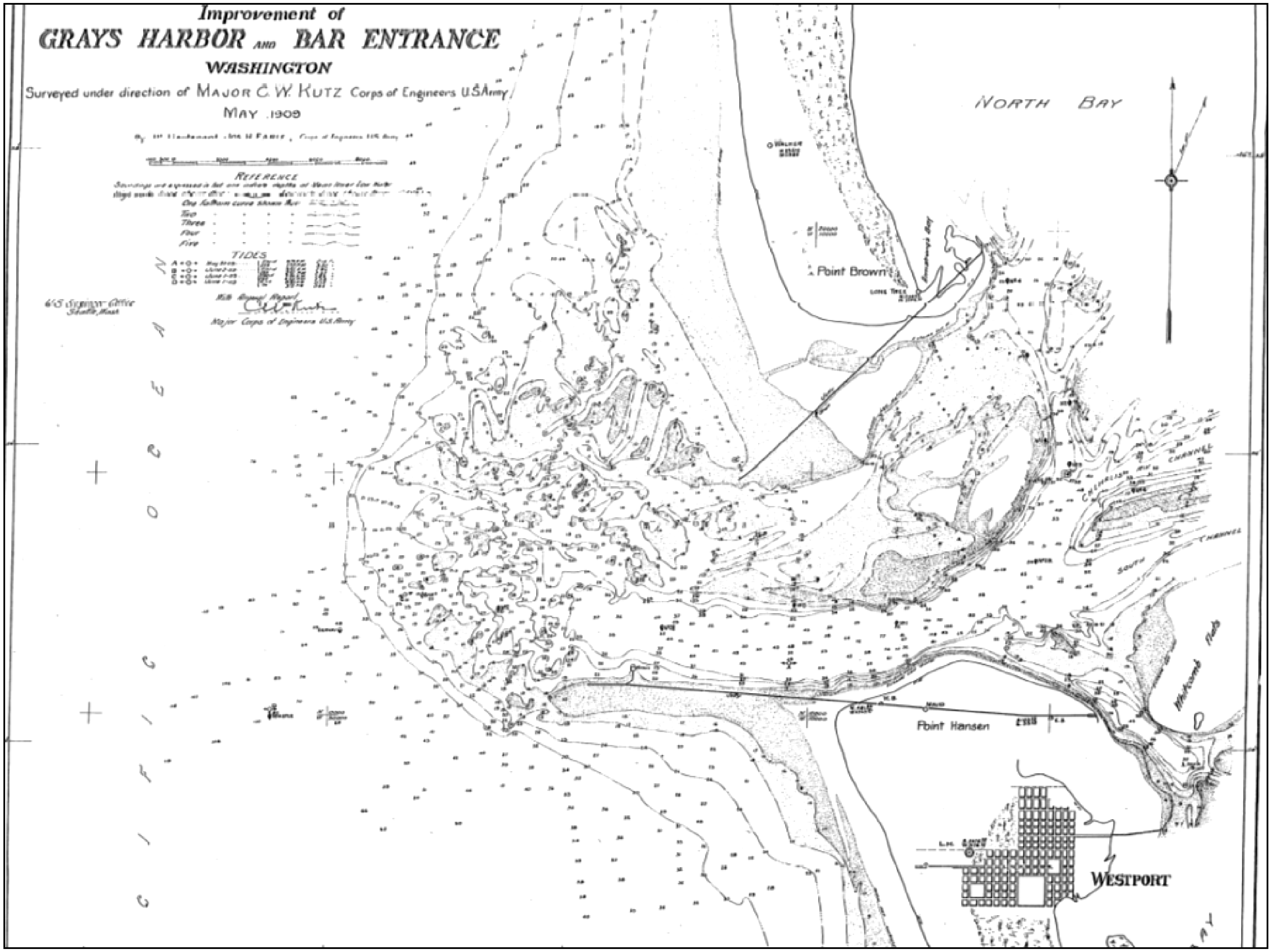

Figure 12: Condition survey from 1909 following original construction of the South Jetty and during construction of the North Jetty. Note no clear channel across ebb tidal shoal indicating unreliable conditions for navigation.

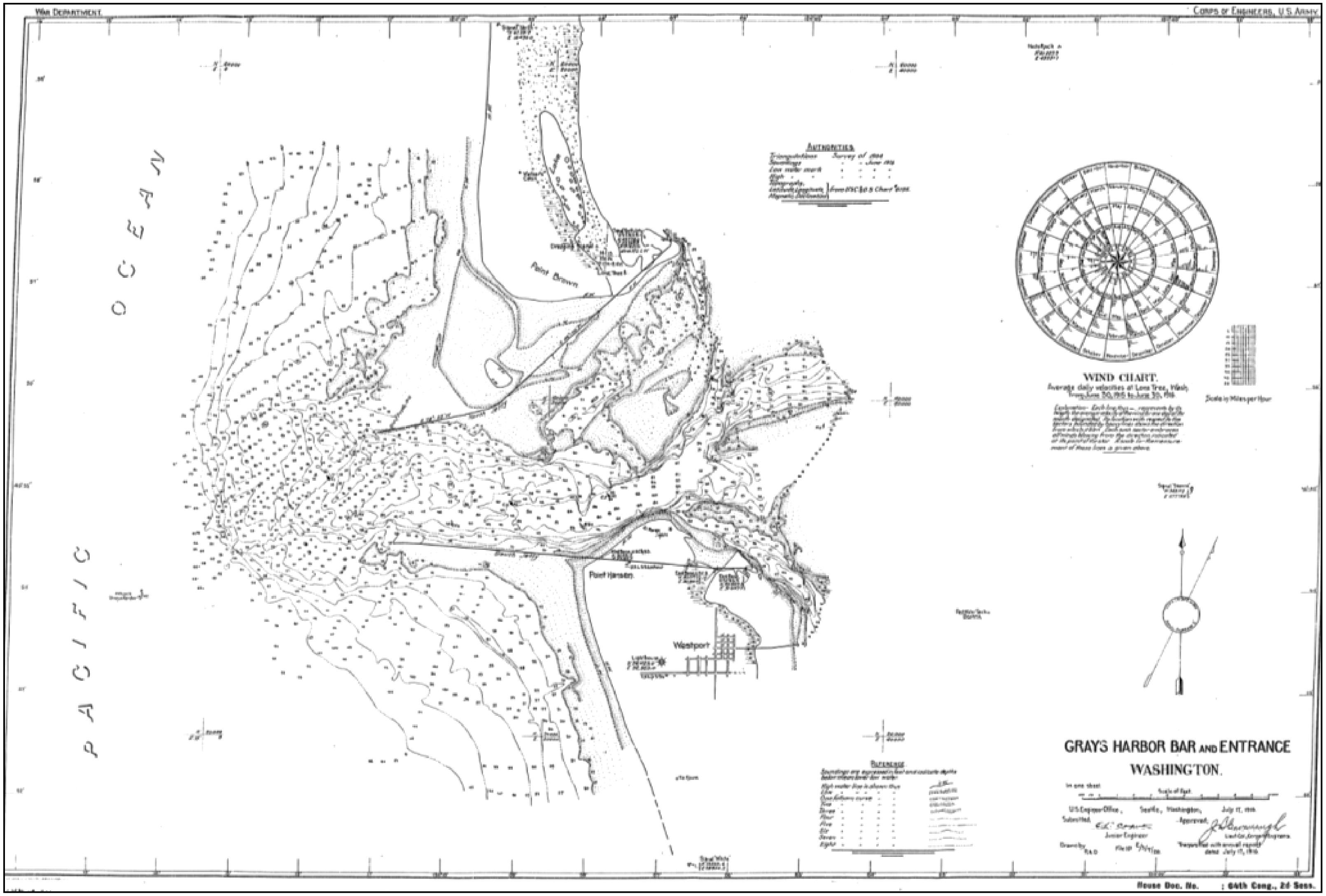

Figure 13: Condition survey from 1916 following original construction of the North jetty. Note ewith presence of the two jetties a clear channel across ebb tidal shoal now exists.

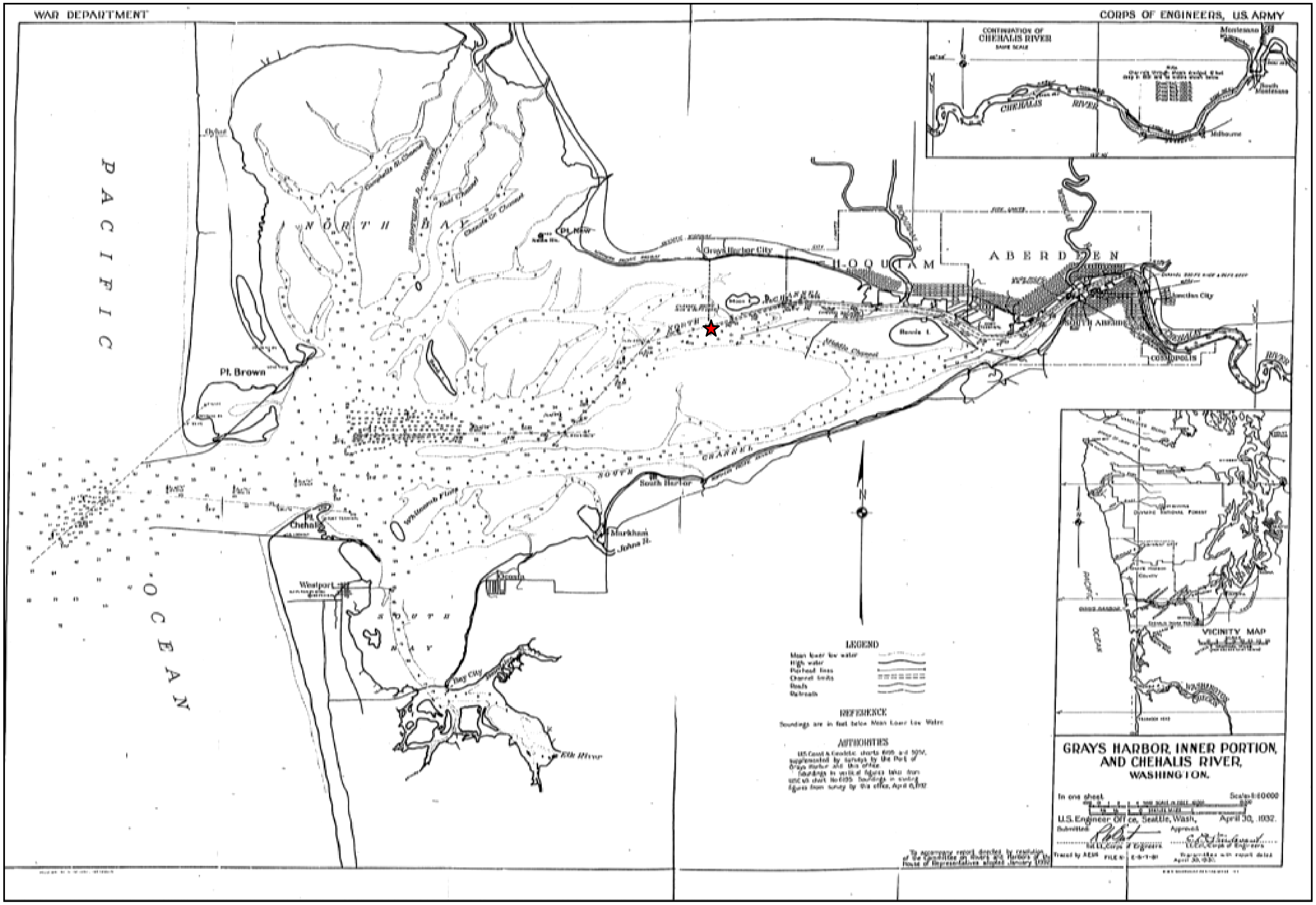

Figure 14: Condition of Grays Harbor in 1932. Star denotes downstream limit of channel maintained by Port of Grays Harbor until 1934 (North Channel).

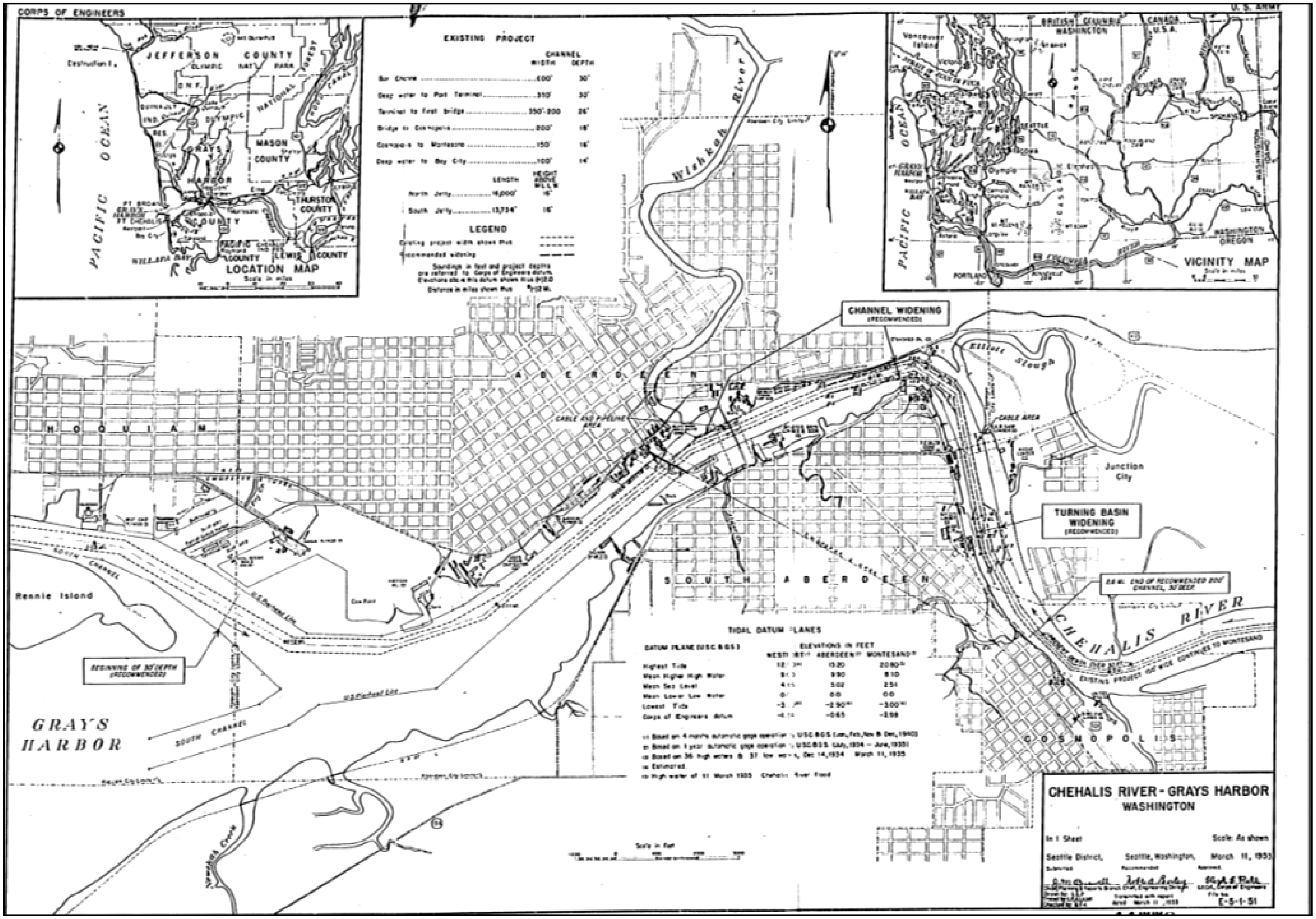

Figure 15: Channel Improvements from Cow Point to South Aberdeen and widening of Elliott Slough Turning Basin

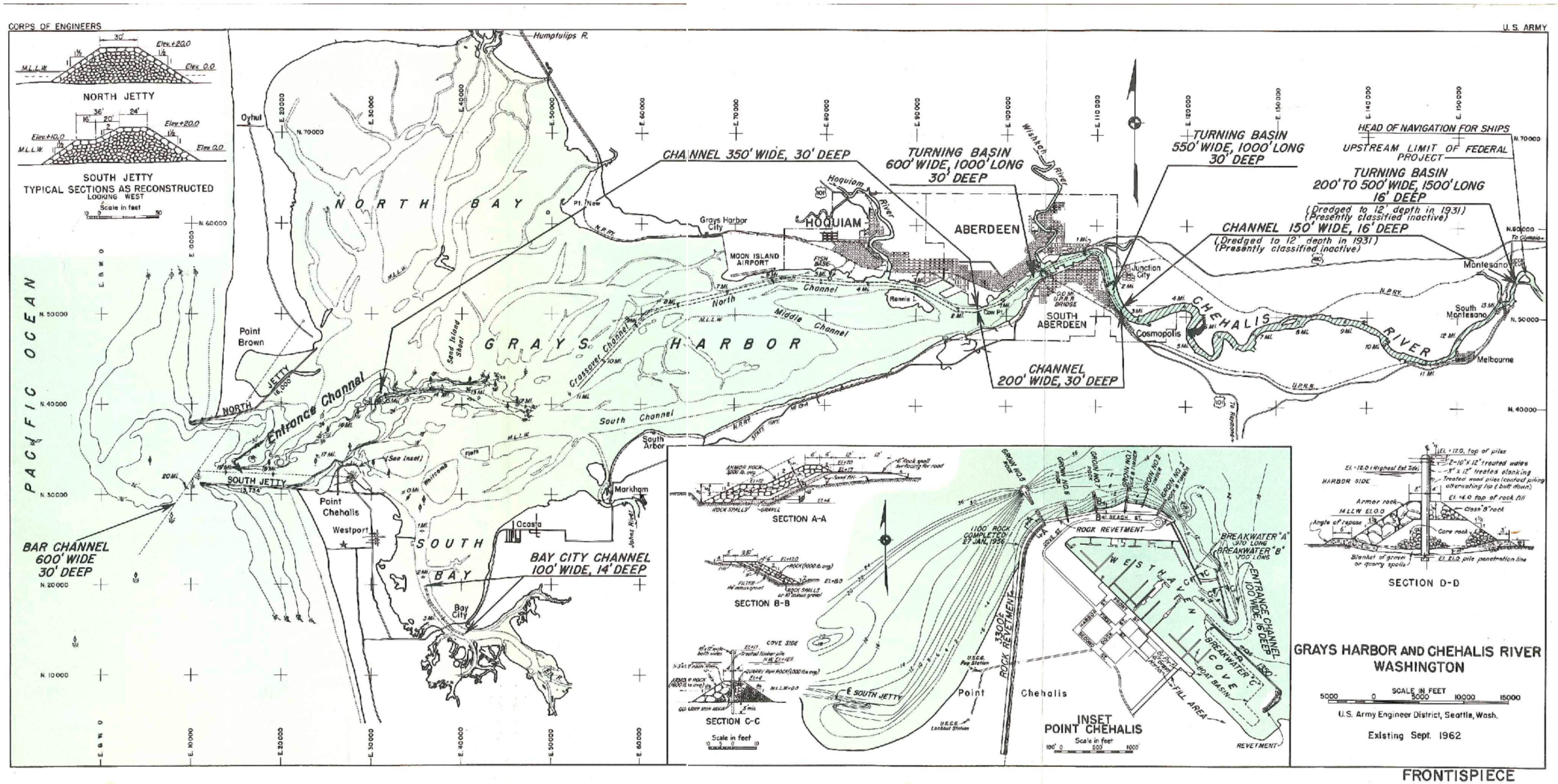

Figure 16: Channel condition after 1954 channel improvements

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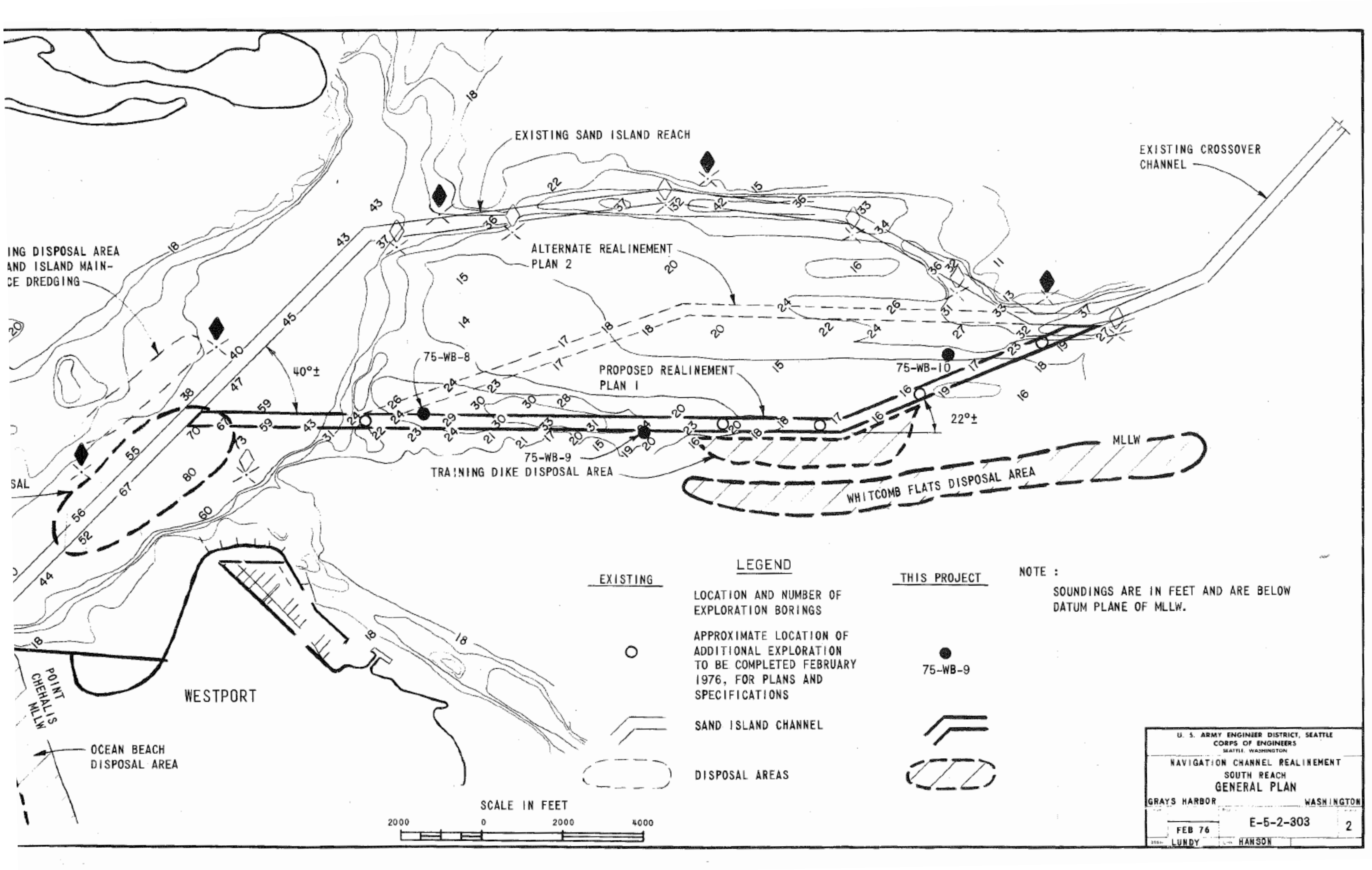

Figure 17: South Reach Channel Realignment in 1976.

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Table 5: Construction and Rehabilitation History, Grays Harbor, Washington (modified from Kraus and Arden 2003)

3 June 1896	The River and Harbor Act authorized the original Grays Harbor navigation project, including a channel across the bar (self-scouring to a depth of about 18 feet mean lower low water (MLLW) and construction of a single jetty extending 18,154 feet seaward from Point Hansen (now called Point Chehalis) peninsula along the southern margin of the entrance to Grays Harbor. At this time, predominant longshore transport was determined to be from south-to-north, and the South Jetty was considered responsible for preventing shoaling in the navigation bar channel (USACE1965).
1898 – 1902	The South Jetty was constructed between May 1898 and September 1902. It was completed to a height of +8 feet MLLW and a total length of 13,734 feet, of which 11,950 feet extended seaward of the high-water line in 1902. During construction, the channel adjacent to the jetty undermined the structure causing material overruns that depleted project funds before the design length of 18,154 feet could be reached. A groin (spur) pointing into the channel was constructed 11,952 feet from the high-water line in 1902.
1902 – 1906	Between 1898 and 1904, depth over the ebb-shoal increased from 12 to 22 feet MLLW as a result of jetty construction, meeting the stated purpose of the project. In addition, the beach south of the jetty accreted, creating a 3,000-feet seaward progradation of the high-water shoreline. However, deterioration of the jetty began around 1904. By 1906, the South Jetty had settled due to scour, and the bar channel began to widen and shoal. This unfavorable shoaling led to construction of the North Jetty
2 March 1907	The River and Harbor Act authorized construction of the North Jetty 9,000 feet long from the ordinary high-water line to an elevation of +5 feet MLLW and 18-foot deep navigation channel.
1907 – 1910	Construction of 10,000 feet of the North Jetty completed to +5 feet MLLW.
25 June 1910	The River and Harbor Act authorized an extension of 7,000 feet to the North Jetty.
1910 – 1913	The North Jetty was completed to a project length of 16,000 feet and an elevation of +5 feet
1913 – 1916	The North Jetty was reconstructed to +8 feet MLLW and extended to a length of 17,204 feet. Construction period for the entire jetty extends from May 1907 to January 1916. After reconstruction of the North Jetty, the channel adjacent to the South Jetty shoaled, and a new wider and deeper channel developed north of the old channel to about -24 feet MLLW. Depth over the bar was again about -22 feet MLLW, and it remained that way until about 1924.
8 August 1917	River and Harbor Act authorized dredging of the bar channel.
1916	As jetties continued to deteriorate and were inadequate to maintain project dimensions in the bar channel, dredging commenced (57,000 cu yd) and continued at regular intervals until 1926 (except for 1918 and 1919).
1926 - 1942	The bar channel required almost continuous dredging between 1926 and 1942. The total quantity dredged from the entrance between 1916 and 1942 was approximately 22 x 10^6 cu yd; maximum dredging occurred between 1934 and 1936. The minimum quantity dredged in a year was 22,000 cu yd, and the maximum was 1,964,000 cu yd (USACE 1967).
1933	By 1933, the South Jetty had subsided to an average depth of 5 to 10 feet below MLLW (+6 feet MLLW at the high-water shoreline and -10 feet MLLW at the outer end).
1934	The outer 8,000 feet of the North Jetty, between the high water shoreline and the tip of the jetty, subsided to approximately -1.5 feet MLLW.
30 August 1935	River and Harbor Act authorized reconstruction of the north and south jetties and maintenance of a 26-foot deep channel below Aberdeen.
1935 – 1939	A 12,656-feet section of the South Jetty (about Sta. 80+00 to 220+00) was reconstructed to an elevation of +20 feet MLLW. Jetty reconstruction blocked the supply of sand to Point Chehalis, causing serious erosion of Point Chehalis. A 32-foot section of the jetty was removed to try to restore the supply of sand, but it was quickly blocked by accretion south of the jetty.
1939 – 1946	The outer 900 feet of the South Jetty was destroyed, and crest rock was displaced to +2 feet MLLW over the next 2,656 feet.
1940	The inner 7,300 feet of the North Jetty, shoreward of the high-water shoreline, was impounded with sand.
1941 - 1942	The North Jetty was reconstructed between February 1941 and May 1942 to +20 feet MLLW for 7,700 feet seaward of the high-water shoreline, then +30 feet MLLW for an additional 528 feet. A 412 feet segment seaward of the reconstructed section was at MLLW and was not restored. The structure landward of the high-water shoreline was not rebuilt.
1942	Maintenance dredging of the bar and entrance channels was no longer required due to scouring effects of the jetties.

[1] Reconstructed refers to major changes in jetty dimensions along the length of the structure.
[2] Rehabilitated refers to changes implemented to maintain a portion of the jetty and its general dimensions.

Table 5 (Concluded)	
1942 – 1949	The outer 325 feet of the North Jetty was leveled, and about 400 feet of the reconstructed section was lowered 4 feet below grade.
1946 – 1951	An additional 900 feet of the South Jetty was destroyed, and the next 4,100 feet subsided to 0 to +10
1946	Half Moon Bay begins to form east of the South Jetty root
1950-1956	Construction of Point Chehalis Revetment and Groins to serve as shore protection for marina at Westport due to erosion associated with South Jetty reconstruction.
1951 – 1953	An additional 900 feet of the outer South Jetty was destroyed, and the next 4,500 feet subsided to 0 to 2 feet MLLW. The next 2,400 feet subsided to +4 feet MLLW.
1949 - 1953	An additional 325 feet of outer end of the North Jetty was leveled, and more than 1,000 feet of the remaining section subsided to +10 feet MLLW.
1952 - 1954	More than 300 feet of the South Jetty (between Sta. 70+00 and 80+00) was dismantled, and the rock used for construction of the Point Chehalis revetment.
1959	An additional 30 x 10^6 cu yd of sand had accumulated north of the North Jetty as a result of jetty reconstruction completed in 1942.
1961	Only 2,100 feet of the reconstructed portion of the North Jetty remained at or near grade (+20 feet MLLW).
1962	By April 1962, average elevation of the South Jetty between 135+00 and 198+00 (6,300 feet) was about MLLW; seaward of this point from 198+00 to 220+00 (2,200 feet), crest elevation ranged from -6 feet MLLW to -48 feet MLLW. The landward section from about 88+00 (high-water shoreline) to 135+00 (4,700 feet) was near grade.
1966	A 4,000-feet section of the South Jetty (from Sta.110+00 to 150+00) was rehabilitated to +20 feet MLLW, leaving the outer 7,000 feet in a degraded condition (-10 feet MLLW or deeper).
1970-1973	Extensive groin replacement , revetment repair, and timber breakwater construction along Point Chehalis (including timber pile closure of Westport Marina entrance between breakwaters A and B)
1974	A section of the North Jetty, about 1,300 feet seaward of the high-water shoreline, ranged from +3 to +14 feet MLLW. The jetty seaward of this point was below MLLW.
1975 - 1976	A 6,000-feet section of the North Jetty, from the high-water shoreline seaward, was rehabilitated to an elevation of +20 MLLW.
1990	Construction of outer harbor navigation channel improvements including deepening of bar and outer entrance channel to 46 feet MLLW, widening of bar channel to 1000 feet, and entrance channel to 600 feet. Deepening of inner harbor reaches and turning basins from 30 feet MLLW to 36 feet.
1991	Maintenance dredging of the bar and entrance channel reactivated.
December 1993	A breach occurred between the ocean and Half Moon Bay adjacent to the South Jetty. The breach was filled with 600,000 cu yd of sand dredged from the channel in 1994.
1993	Rehabilitate southern portion (800 feet) of the Point Chehalis revetment.
March 1999	Storm lowered a 200 feet section of the South Jetty to about +9 feet MLLW and damaged the jetty where it intersected the shoreline.
Dec 1998 – Mar 1999	Pt. Chehalis Revetment Extension Project. Corps extends the Pt. Chehalis Revetment 1900' south along Half Moon Bay.
2000	South Jetty Repair Project. Reinforce South Jetty from Sta. 81+00 to 87+50 to 40 foot crest width. Contract wave diffraction mound at landward root of South Jetty including placement of 17,400 tons of 12" minus gravel/cobble on Half Moon Bay to slow erosion.
1999-2000	A 3,500-feet section of the South Jetty seaward of the high-water shoreline was raised to an elevation of +23 feet MLLW.
2000	North Jetty Major Maintenance Rehabilitation, Sta. 95+00 to 145+00, top el. +23 feet MLLW.
2002-present	Dredged material or upland materials are used to periodically renourish sediment to the dune/beach on Half Moon Bay and South Beach to minimize risk of a breach reoccurring adjacent to the South Jetty. Four Nourishments placing a total of 166,000 cu yd. of sediment have taken place in 2002, 2004, 2010, and 2012.
2010	Repaired two sections (total of 300 feet) of the Point Chehalis Revetment which had been damaged by wave overtopping
2013	Repaired another 300 foot section of the Point Chehalis Revetment which had been damaged by wave overtopping

Operations and Maintenance Dredging (2000 to present)

The Corps of Engineers annually performs O&M dredging of the federal navigation channel using two different dredge types for the outer harbor and inner harbor reaches. These dredged volumes are related to funding allocated to the project in a given year versus the volume available to maintain the navigation channel to the authorized depth. The historic dredging volumes from 2000 to 2012 in the Grays Harbor navigation channel are listed by reach in Table 6.

The outer harbor reaches from the Bar to the Outer Crossover are dredged with a hydraulic hopper dredge which can operate in harsher conditions. The Corps typically operates two government hopper dredges, the Yaquina and the Essayons, in the outer harbor; howeve,r private hopper dredges have been utilized in the past. The load capacity of these dredges ranges from 1,000 to 6,000 cubic yards with an average daily production ranging from 10,000 to 30,000 cubic yards per day. The timing of hopper dredging has historically been in the months of April and May. This is typically due to the scheduling of the government dredges which are shared among the Corps Districts on the West Coast. O&M dredged material from the outer harbor is placed at four different open water placement sites: the Point Chehalis Site, South Jetty Site, South Beach Beneficial Use Site, and the Half Moon Bay Beneficial Use Site. The average annual volume dredged from the outer harbor from 2000 to 2012 was 887,600 cubic yards. The maximum dredged was 1.24 million cubic yards in 2000.

Historically the inner harbor reaches from the Inner Crossover to Cow Point has been dredged via clamshell dredge which is a mitigation requirement for juvenile crabs. The Outer Crossover may be dredged via hopper or clamshell dredge; clamshell dredging is the preferred method however hopper dredges have historically dredged this reach due to the timing of the clamshell dredging which typically requires more exposure to adverse weather conditions. Clamshell dredging is performed with a private Contractor dredge within the fish window extending from 15 July to 14 February. Dredged material is transported by a tug from the dredge area and placed at the Point Chehalis or South Jetty open water placement site by a bottom dump scow barge. Recently the Contract dredge has utilized a 35 cubic yard clamshell bucket with 2 bottom dump barges and has achieved an average daily production of approximately 12,000 cubic yards per day. The average annual volume dredged from the inner harbor from 2000 to 2012 was 997,500 cubic yards, while the maximum dredged was 1.62 million cubic yards in 2004.

	Clam Shell Dredging (Inner Harbor) Volume (yd^3)							Hopper Dredging (Outer Harbor) Volume (yd^3)				Total Volumes (yd^3)	
Dredge Year	**S. Aberdeen**	**Elliot Slough Turning Basin**	**Cow Point / Aberdeen**	**Cow Point Turning Basin**	**Hoquiam**	**North Channel**	**Inner Crossover**	**Outer Crossover**	**South Reach**	**Entrance / Pt Chehalis**	**Bar Channel**	**Inner Harbor**	**Outer Harbor**
2000	-	-	443,518	-	54,376	200,000	218,163	295,837	198,000	537,000	209,000	916,057	1,239,837
2001	-	-	271,303	-	42,777	-	-	162,654	191,209	359,000	227,000	314,080	939,863
2002	-	61,279	705,114	-	115,901	126,780	158,838	22,129	135,706	605,459	144,031	1,167,912	907,325
2003	-	-	549,026	-	128,874	146,794	301,819	-	135,634	246,792	137,689	1,126,513	520,115
2004	-	35,619	784,950	-	135,863	113,633	545,896	175,968	177,529	443,470	291,195	1,615,961	1,088,162
2005	-	-	657,352	-	141,746	143,760	223,542	107,432	-	622,771	217,909	1,166,400	948,112
2006	-	27,869	638,343	-	37,863	93,825	200,488	163,730	59,931	379,513	55,170	998,388	658,344
2007	-	-	418,564	-	-	-	-	117,560	94,868	497,795	-	418,564	710,223
2008	-	-	694,536	208,069	-	-	198,471	-	-	800,258	-	1,101,076	800,258
2009	-	-	626,247	200,000	-	-	268,179	-	-	684,107	246,873	1,094,426	930,980
2010	-	-	716,449	171,295	150,000	150,000	198,529	-	67,102	580,218	118,182	1,386,273	765,502
2011	-	-	521,646	83,853	122,288	104,765	-	-	46,670	459,840	298,163	832,552	804,673
2012	-	-	451,291	177,185	96,846	103,598	-	-	27,475	1,056,333	141,655	828,920	1,225,463
Sum	**-**	**124,767**	**7,478,339**	**840,402**	**1,026,534**	**1,183,155**	**2,313,925**	**1,045,310**	**1,134,124**	**7,272,556**	**2,086,867**	**12,967,122**	**11,538,857**
Average	**-**	**9,600**	**575,300**	**64,600**	**79,000**	**91,000**	**178,000**	**80,400**	**87,200**	**559,400**	**160,500**	**997,500**	**887,600**
Max	**-**	**61,279**	**784,950**	**208,069**	**150,000**	**200,000**	**545,896**	**295,837**	**198,000**	**1,056,333**	**298,163**	**1,615,961**	**1,239,837**

Table 6: Annual Grays Harbor Navigation Channel Paid Dredge Volumes (FY 2000 - FY 2012)

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2.3. Harbor morphology

Grays Harbor is located within the Columbia River littoral cell which extends over 100 miles of shoreline between two rock headlands; Tillamook Head in Northwest Oregon to Point Grenville in Southwest Washington. The majority of sediments within the littoral cell derive from the Columbia River. The net direction of longshore (littoral) transport in the cell is from south to north. Construction of two rock jetties at the Mouth of the Columbia River and at Grays Harbor near the turn of the 20th century significantly changed littoral transport patterns within the Columbia River littoral cell. At Grays Harbor, jetty construction resulted in inlet narrowing and deepening to sustain safe and reliable navigation into the harbor. As the inlet was constricted, sediments from the mouth of the inlet were scoured and transported offshore resulting in an offshore migration of the ebb tidal delta and massive accretion of the shorelines flanking the jetties. Subsequently, the physical barrier of the jetty and the migration of the ebb tidal delta offshore, the once connected shoal on the updrift (southern) side of the inlet lost connection to the ebb tidal delta and altered the process which historically bypassed sediment across the inlet. As a result the sediment exchange across adjacent shorelines within the littoral cell diminished (Kaminsky et al. 2010). As shown in Figure 18, construction of the north and south jetties from 1898 to 1916 resulted in over 30 feet (~10 m) of scour in portions of the entrance channel between the jetties (erosion denoted by hot colors) as the entrance was confined. Accretion was experienced offshore of the convex shaped ebb tidal delta, Point Chehalis, Damon Point, to the South Beach nearshore region, and to the North Beach nearshore region (accretion is denoted by cool colors). This resulted in significant shoreline advances on North Beach and South Beach shorelines which is discussed in more detail in Section 2.3.1.1.

The jetties were originally constructed to high water using materials which were eventually displaced by currents and waves. On the south side of the inlet, deterioration of the South Jetty resulted in transport of sands over and through the jetty which and fed the growth of the spit at Point Chehalis to the north. However following reconstruction of the South Jetty in 1939 tidal currents were strengthened and the sediment over and through the South Jetty was blocked. As a result this initiated severe erosion of Point Chehalis and the formation of Half Moon Bay. On the north side of the inlet, deterioration of the North Jetty resulted in southern littoral transport over and through the jetty and resulted in the formation and growth of Damon Point inside the harbor. Following reconstruction of the North Jetty in 1942, analogous to Point Chehalis on the south, erosion of the spit at Damon Point occurred once the southerly sediment transport over and through the North Jetty was cutoff. This continued until the North Jetty again began to deteriorate allowing southerly sediment transport back into the harbor. At the same time the North Beach shoreline had advanced seaward enough to begin bypassing sediment around the terminus North Jetty during flood tides further supplementing the sediment source to Damon Point. This led to the progressive advancement of Damon Point to the southeast and resulted in increased shoaling in the Bar, Entrance, and Sand Island Reaches of the navigation channel. As a result this forced the thalweg to the south of the harbor away from the historic position which was adjacent to Sand Island. In 1976, this prompted the Corps of Engineers to rehabilitate the North Jetty and realign the navigation channel from the former position adjacent to Sand Island to a location adjacent to Whitcomb Flats.

In 1990, the channel deepening and widening project deepened the navigation channel across the Bar and Entrance reaches from -36 feet MLLW to -46 feet MLLW. The result of this activity has resulted in increased O&M dredging in these channel reaches since construction. Additionally, the deeper channel depths have resulted in larger wave energy transmitted into the harbor. This has had influence on the wave climate experienced at Point Chehalis and the morphology of the flood tidal shoals (Whitcomb Flats) which is discussed in more detail in Section 2.3.1.2.

From 1954 to 1999 the accretion to the South Beach nearshore reversed and began to erode. Persistent recession to South Beach and Half Moon Bay shorelines culminated with a breach which disconnected to South Jetty from land in December 1993. The Corps filled the breach in 1994 with approximately 600,000 cubic yards of dredged materials. Since, 1994 the Corps has utilized nearshore placement of dredged material and direct beach and dune nourishment to mitigate the erosive trends and reduce the risk of long-term impacts to the navigation channel.

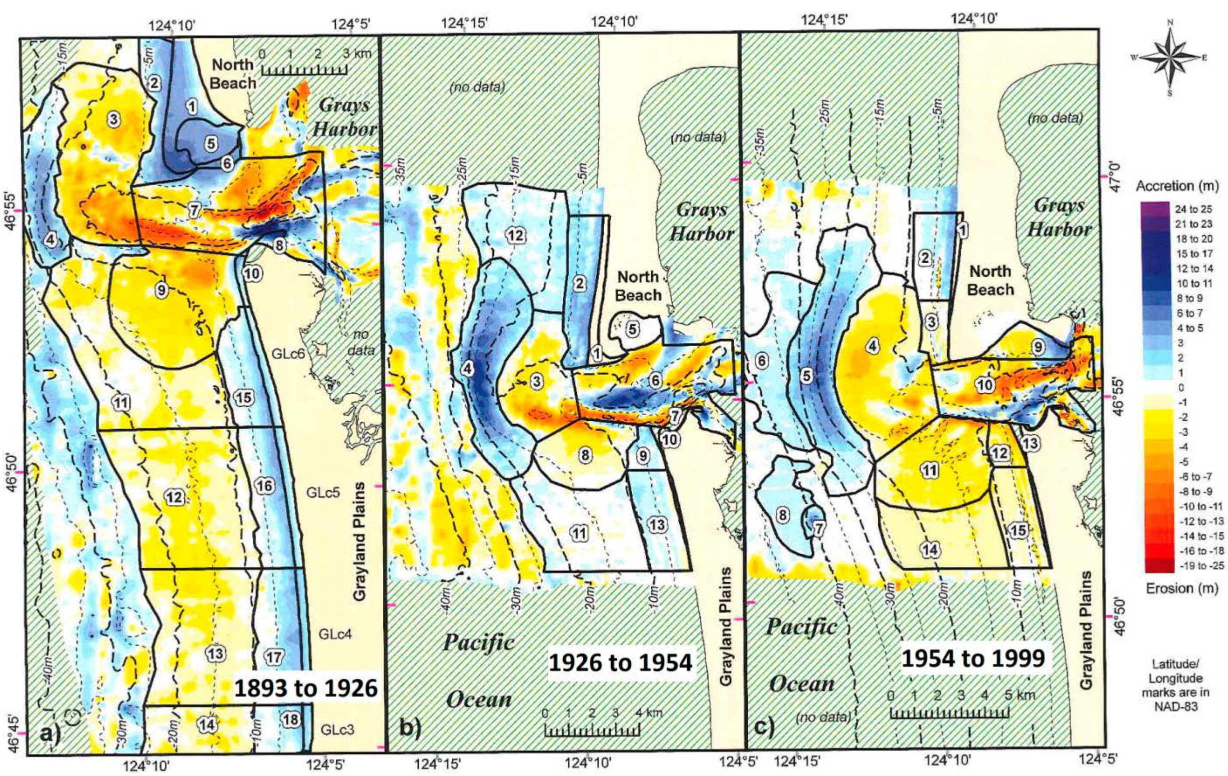

Figure 18: Grays Harbor bathymetric changes from 1893 to 1999 (from Kaminsky et al. 2010)

2.3.1.1. Shoreline change

The shoreline on both the north and south sides of the entrance to Grays Harbor have undergone major changes since the Corps constructed the North and South Jetties between 1898 and 1916 in an effort to minimize dredging requirements for the deep-draft Federal Navigation Channel. Construction of the jetties constricted the inlet to Grays Harbor, which increased the tidal currents in the entrance channel and moved the ebb-tidal delta offshore (Kraus and Arden 2003; Buijsman et al. 2003). As shown in Figure 19a and Figure 20a, by 1916 the South Beach shoreline had witnessed 2,190 feet and by 1942 North Beach had witnessed 7,640 feet of accretion oceanward as a result of entrance materials introduced into the nearshore system.

As shown in Figure 21, prior to 1954 the shoreline adjacent to the jetty (GLdn) had accreted at a rate of over 10 feet (3 m) per year. This was primarily in response to the large influx of sediments introduced into the nearshore region following jetty construction. After 1954, this trend reversed and the shoreline began receding at a rate of approximately 10 feet per year. This reversal is attributed to changes in littoral drift patterns and steepening of the nearshore area. On the north side of the harbor the North Beach shoreline has experienced continuous accretion between 1700 and 1999. The shoreline adjacent to the North Jetty (NBds) experienced a shoreline accretion rate of approximately 100 feet (30 m) per year in the interval from 1885 to 1926, which is during the time frame the jetties were originally constructed. This accretion rate has decreased to approximately 13 feet (4 m) per year from 1951 to 1999.

Inside the harbor between 1898 and 1936 a substantial volume of sediment was transported over and through the South Jetty. This was a result of a low crest height and progressive deterioration of the South Jetty. The sediment deposited just north of the South Jetty resulted in the northward growth of the Point Chehalis shoreline (Figure 20b). With this newly accreted peninsula, the Port of Grays Harbor constructed a small boat basin on the east side of Point Chehalis in 1929, named Westhaven Cove. However, reconstruction of the South Jetty in 1935-1939 raised the height of the jetty and eliminated this sediment source to Point Chehalis. After this sediment source was cut off this resulted in considerable erosion of the west and north sides of the Point Chehalis by tidal currents and wave action. By 1946 the shoreline formation of present day Half Moon Bay had been established (Figure 20c). In 1952 in effort to protect Westhaven Cove, shoreline recession at Point Chehalis was stopped through measures which included deconstructing the outer 1800 feet of the South Jetty and constructing a rock revetment and groins on the shoreline of Point Chehalis. However, erosion still continued near the landward root of the South Jetty resulting in a progressive narrowing of the dune separating the Pacific Ocean with Half Moon Bay.

Damon Point is a long low relief sand spit which presently extends 1.9 miles southeast from the landward root of the Grays Harbor North Jetty. The formation of the spit was a direct result of construction of the North Jetty. The North Jetty was originally constructed in 1916 to a height of +8 feet above mean lower low water (MLLW), or approximately to mean higher high water. During high water levels the jetty was submerged and allowed sediment to be transported through and over the structure. Over time the prevailing northwesterly waves transported this sediment over and through the North Jetty and served as the original source of sediment which initially formed the sand spit at Damon Point. The rate of growth of Damon Point accelerated as the North Jetty deteriorated from wave attack. By 1942, Damon Point extended approximately 1 mile east from the North Jetty (Figure 19b).

The first major rehabilitation of the North Jetty was completed in 1942 and the jetty was raised to +20 feet MLLW. This rehabilitation effectively cut off the sediment source which historically supplied sediment to Damon Point. As a result the spit began to migrate eastward and became less prominent in area and eventually culminated in a breach separating the spit from the root of the North Jetty in 1944 (Figure 19c).

By 1950 the shoreline north of the jetty advanced seaward to a position which allowed sand to be transported around the jetties seaward terminus and bypassed sediment eastward back into the harbor. This process renewed the sediment source to Damon Point and again began to grow the spit to the southeast. This process has continued up until about 1998. Currently the rate of longshore transport along the Damon Point spit is presently greater than the supply of sediment from the shoreline north of the jetty. This has resulted in gradual elongation and narrowing of the spit (Figure 22 and Figure 23). The narrowing of the spit eventually led to two overwash events in 1997 and 1998 and was at that time speculated to be the precursor of a future breach of Damon Point (Kaminsky et al. 1999). During a storm in December 2007 the narrowest section of Damon Point was overwashed again and resulted in the ultimate closure of the State Park road along Damon Point.

Since 2006 the erosion to the northwest shoreline of Damon Point has been significant. Over 500 feet of shoreline retreat occurred between 2006 and 2011 and 150 feet of shoreline retreat has occurred between 2009 and 2011 adjacent to the root of the North Jetty. The average shoreline retreat along the 7,200 feet southeast of the jetty where erosion was observed was calculated at 384 feet (Figure 23). Over this period, this computes to approximately 1.5 million cubic yards of erosion (or 300,000 cubic yards per year).

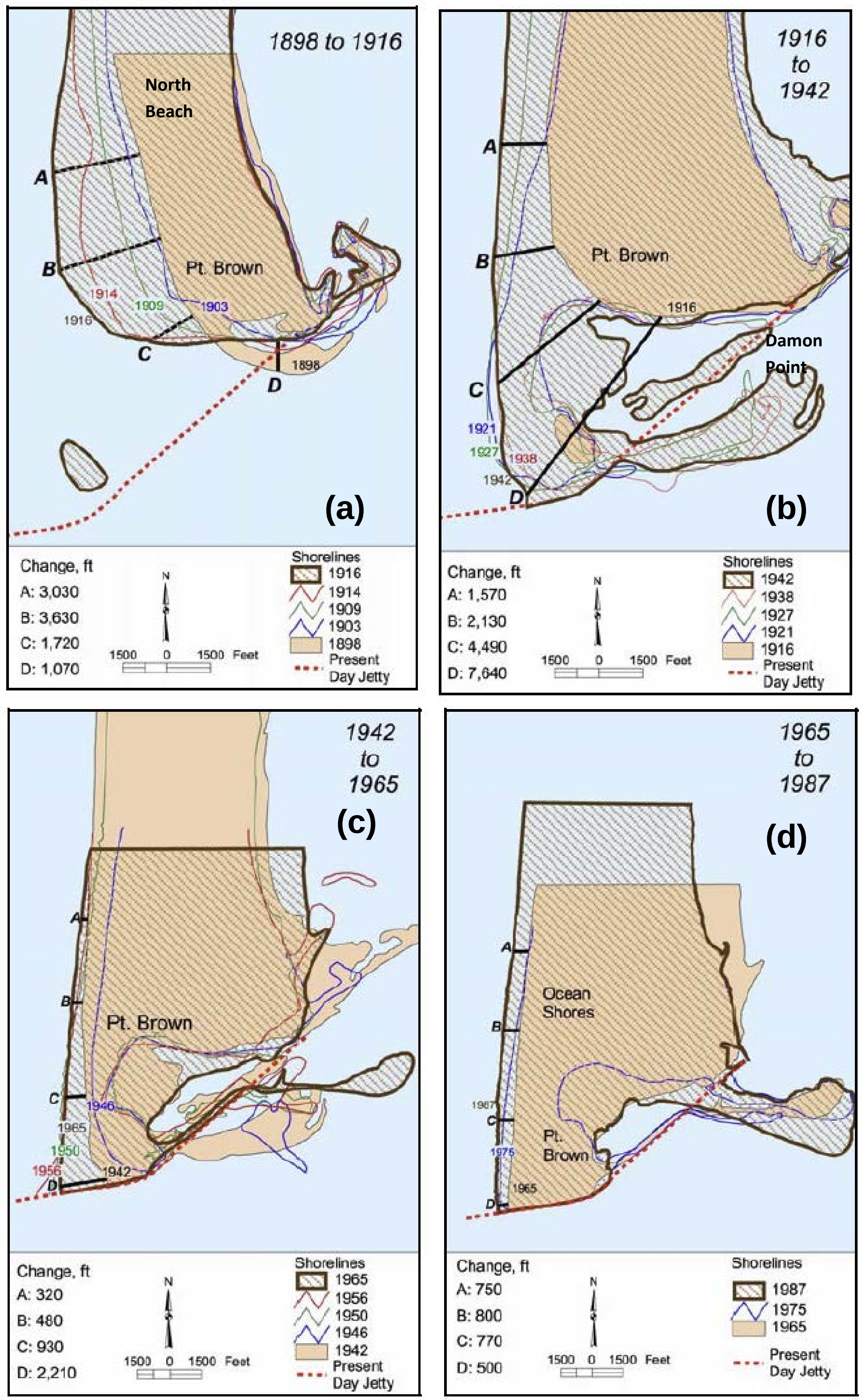

Figure 19: North Beach and Damon Point Shoreline change near the Grays Harbor North Jetty from 1898 to 1987 (from Kraus et al 2003)

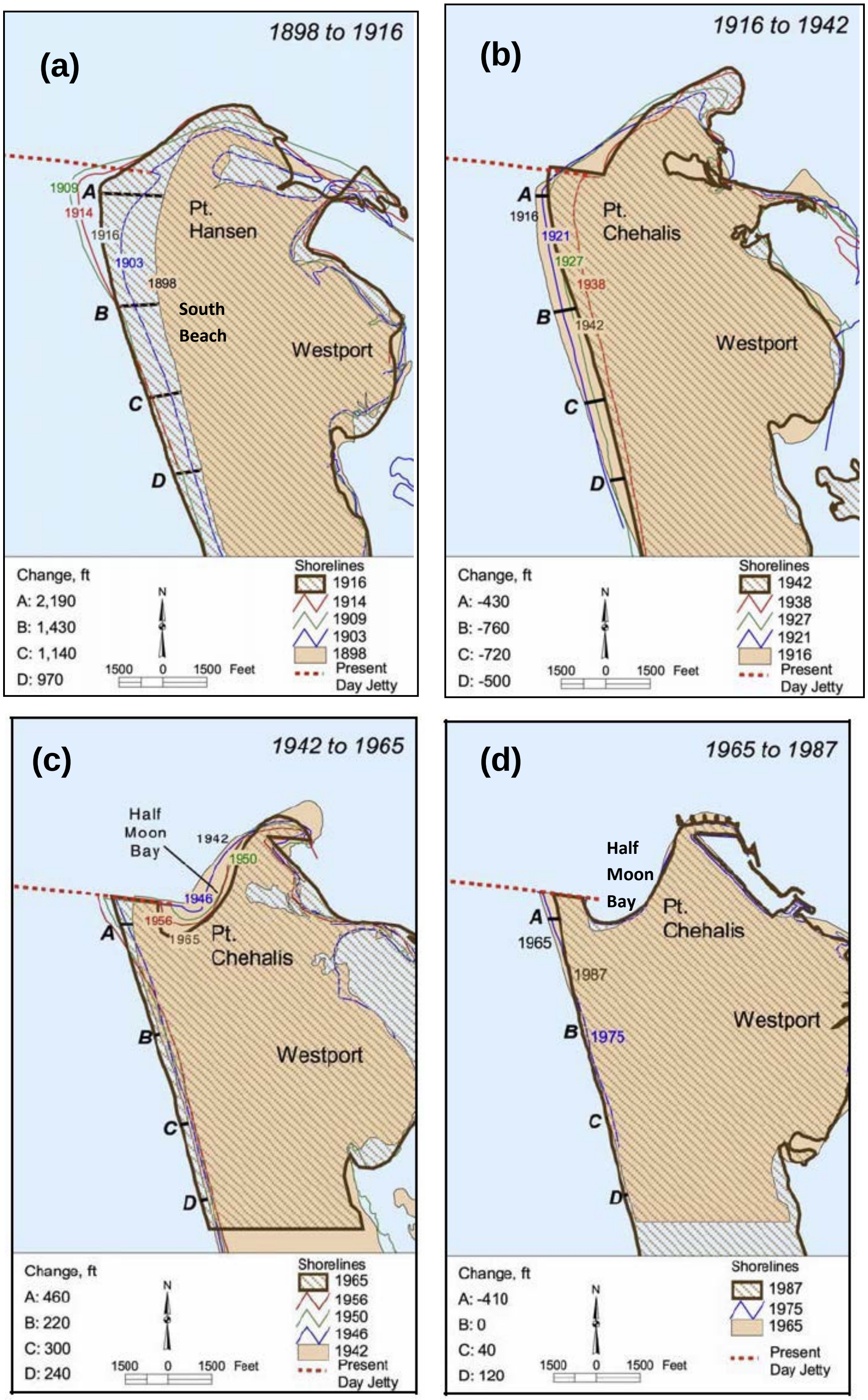

Figure 20: South Beach, Point Chehalis, and Half Moon Bay shoreline change from 1898 to 1987 initial shoreline advancement during jetty construction and equilibrium period immediately following, respectively (from Kraus and Arden 2003)

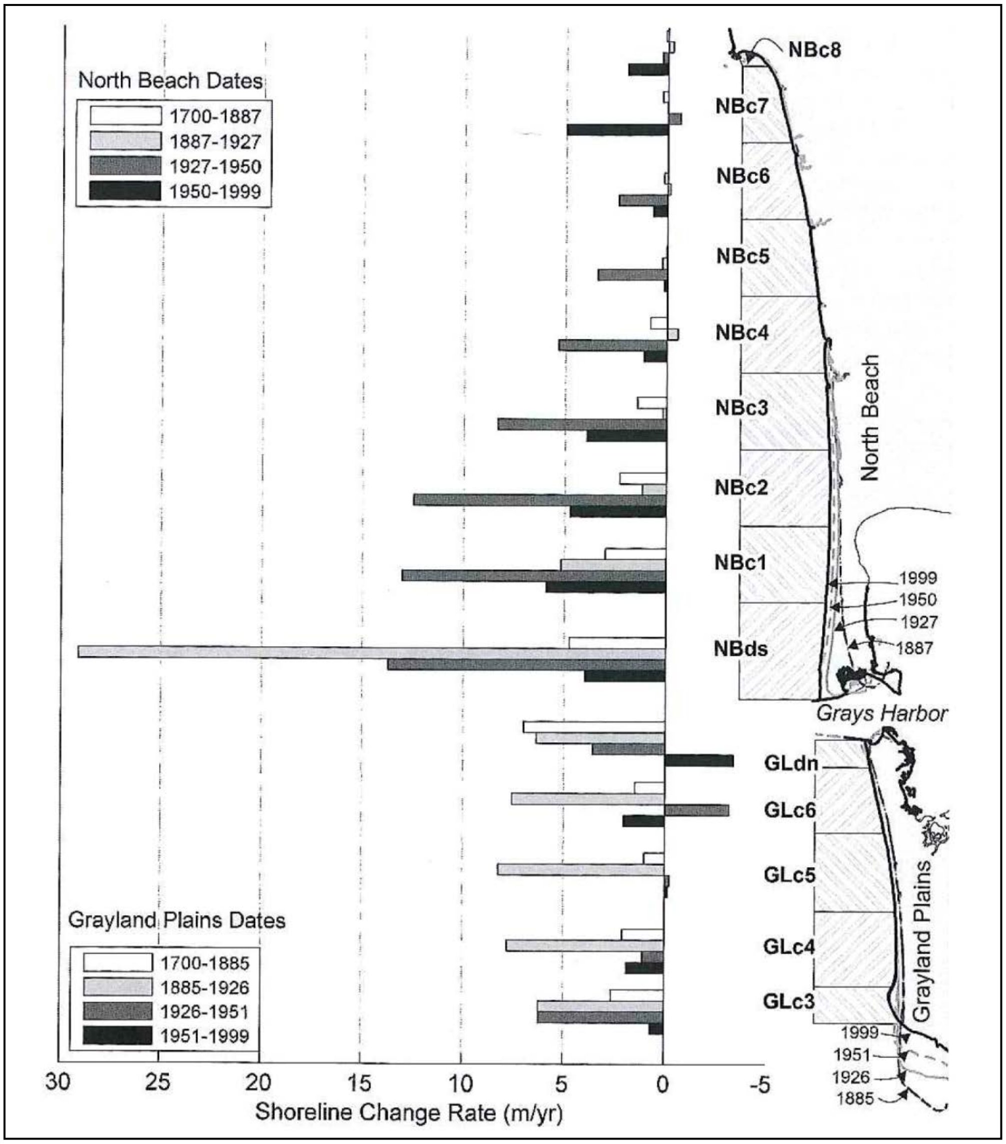

Figure 21: Grays Harbor shoreline change rates over time (from Kaminsky et al. 2010)

Figure 22: Damon Point shoreline position from 1968 to 2009.

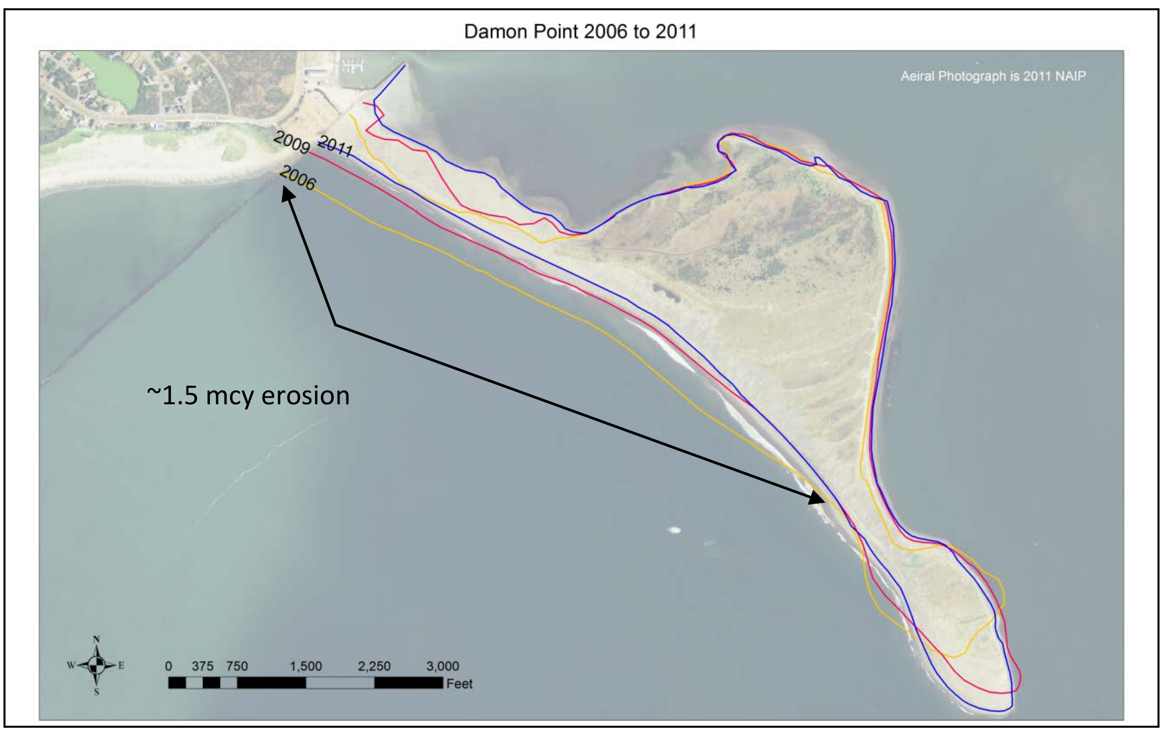

Figure 23: Damon Point shoreline position from 2006 to 2011

2.3.1.2. Flood tidal shoal morphology

Whitcomb Flats

Whitcomb Flats is a flood tidal shoal complex located approximately 1 mile east of Point Chehalis (Figure 1). Its sediments are composed of sand derived of marine origins which were deposited by tidal flood currents and wave-induced transport. The flood shoal has been a long standing land feature within Grays Harbor which predates the navigation project; Whitcomb Flats was mapped in the 1890 condition survey prior to jetty construction in 1898 (Figure 11). Osborne (2003) conducted a geomorphology study on the evolution of Whitcomb Flats using georectified aerial photographs from 1962 to 2001. Figure 24 shows Whitcomb Flats has experienced a net eastward migration over this time period. This migration is tied closely with the morphology of the inlet throat. As discussed in Section 2.2, the deteriorated condition of the North Jetty resulted in significant sediment transport from North Beach over and through the North Jetty. This caused the distal end of Damon Point to grow toward the southeast which is a trend that has continued up until present time (Figure 23). This has in turn constricted the throat of the inlet between Damon Point and Point Chehalis resulted in a net erosion of 40 million cubic yards of sediment from the seabed since 1954 (Figure 18c – polygon 10). The pathways of sediment scoured from the inlet throat have been primarily directed offshore due to the strength of the ebb currents on outgoing tide (Figure 3) and have resulted in a diminished sediment supply to Whitcomb Flats over time. Additionally, as Damon Point continued to grow southeast this also forced the southward migration of the channel thalweg away from the historic Sand Island Reach of the navigation channel (Figure 17). As the thalweg migrated south, the wave transmission into the inner harbor was also altered. Wave model results (Figures 8 and 9) indicate moderate wave transmission into the harbor near Whitcomb Flats for west and northwesterly offshore waves. Thus deepwater wave energy transmitted into the harbor through the inlet throat eventually refracts into the shallows near Whitcomb Flats. The geomorphology analysis suggests these waves can overwash the low-relief sand flat and cause the eastward migration of Whitcomb Flats.

Sand Island

The Sand Island flood tidal shoal complex also predates the navigation project at Grays Harbor. However, unlike Whitcomb Flats the subaqueous shoal fronting Sand Island has been accreting sediment. Between 1987 and 2002 a net deposition of 6.6 million cubic yards was measured (Kraus and Arden 2003). The stability of Sand Island itself can be attributed to the sheltering effect of Damon Point and the Sand Island shoal from wave energy and a well established network of tidal channels in the vicinity of Sand Island.

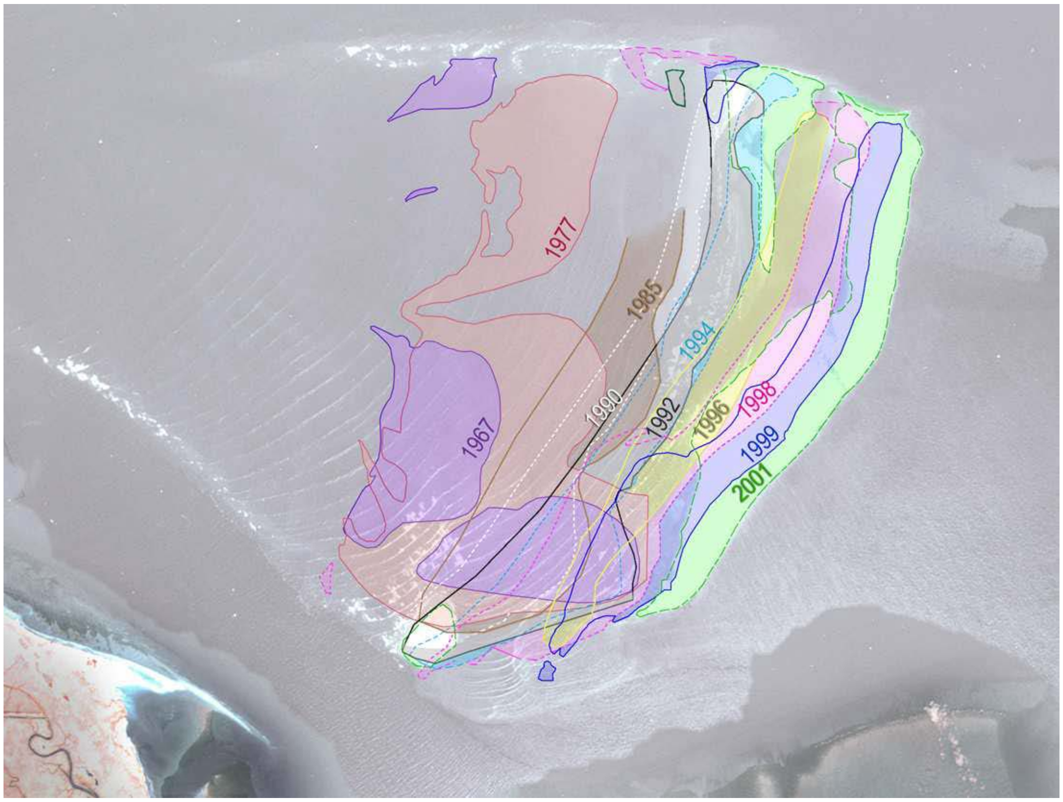

Figure 24: Eastward migration of Whitcomb Flat from 1967 to 2001 (from Osborne 2003)

3. Geology and Soils

General

Development of the present topographic configuration and features in the Grays Harbor area has resulted mainly from drowning of a major coastal river valley and subsequent erosion and deposition of coastal sediments by wave action, tidal and alongshore currents. A geologic history of this area begins with the origin of the regional bedrock. Oscillatory crustal earth movement caused periodic advance and retreat of seas across the plains which were present in western Washington prior to development of the Coast and Cascade Ranges. Both continental and marine sediments were deposited, sometimes associated with volcanic flows. These rocks were later warped and uplifted, and the Olympic Mountains and Willapa Hills were formed. In the present Grays Harbor area, a major stream valley system, the beginning of the present Chehalis Valley, developed on the uplifted land surfaces. Glaciers did not reach this area during the Pleistocene, but a lowering of sea level occurred which resulted in the erosion and deepening of this valley system. As the continental ice retreated, a re-advance of the sea, possibly accompanied by some coastal subsidence, drowned the valley.

Soft sedimentary rock of the headlands north and south of the Grays Harbor embayment was attacked by the sea, and barrier beaches were developed. Detritus, mostly sand with a few gravels, moved along the coast by alongshore currents developed spits extending into the embayment entrance both north and south, Point Brown and Point Chehalis respectively. Tidal currents have maintained a channel between the bay and the sea, and redistributed the fluvial sediments (sand and silt) being deposited within the bay by numerous tributary drainages. The present spit and harbor bottom are, therefore, mostly sand with silty sand and rare gravels. A general description of estuary sediments is shown on Figure 25 by Scheidegger and Phipps (1976).

Subsurface exploration and rippability of sediment in Cow Point Reach

Extensive subsurface explorations have been performed in the channel reaches of the proposed channel improvement in 1975, 1985, and 2012 using vibracores and wash boring cores. All of the subsurface coring results indicated dredgeable soils within authorized depth to -38 feet MLLW from South Reach to Cow Point Reach. However dredging to the maximum allowable depth (i.e. authorized + advanced maintenance + overdepth tolerance) in the Cow Point Reach may be more challenging. USACE (1989) indicates in the Cow Point Beach “gravels are underlain by sandstone bedrock”. The highest bedrock surface, elevation -36 feet, was found at Sta. 1231+06 on the channel centerline which is upstream of the project limit of Sta. 1227+99.

Three foundation explorations from 1985 were found to have refusal above the maximum allowable depth of -42 feet MLLW within the project limits. The only channel reaches where sandstone refusal was observed to occur above the authorized depth of -38 feet MLLW is upstream of 1227+99. Test hole locations 85-VC-18, 85-VC-17, and 85-WB-21 observed refusal in depths ranging from -39.9 to -41.5 feet MLLW, and were located between Sta.

1212+00 to 1223+00 adjacent to the Port of Grays Harbor Terminal 4 (Figure 26). In these test holes a top layer of silts was underlain by sandy gravel prior to refusal on the sandstone. Recent explorations from 2012 indicate refusal of the vibracore above -42 feet MLLW from Sta. 1200+00 to 1215+00 (Figure 27).

The sandstone unit is part of the Miocene Montesanso Formation (Laprade and Robinson 1989). The sandstone is classified as soft and “almost soil-like” and has previously been quarried for foundation fill in the Grays Harbor area. Geophysical logs (Brocher and Christensen 2001) of the Montesano formation collected north of Aberdeen, Washington indicate average sonic velocities of 2.4 km/s and an average density of 2230 kg/m3 (140 pcf). Rippability graphs published (Caterpillar 2010) show seismic velocities between 2.1 and 2.9 km/s with marginal rippability for sandstone.

A clamshell dredge cannot rip, but an excavator or hydraulic cutter head dredge can rip. Thus attaining the 2 feet of advanced maintenance dredge allowance from Station 1200+00 to 1223+00 may require the use of an excavator or hydraulic cutterhead dredge. Dredge productivity was measured by the Corps at 10 test pits in areas of hard sandstone in the Arthur Kill Channel within New York Harbor (Murphy et al. 2011). The seismic velocity through the sandstone formation exceeded 2.7 km/s in the dredge area. Test pits were dredged to depths of -53.5 feet MLLW with an excavator and production varied from 2.6 to 35.9 cubic yards per hour using a 1 cubic yard bucket.

At Grays Harbor, the seismic velocities are lower suggesting better rippability and production of sandstone present within the dredge prism between -40 and -42 feet MLLW. In order to gather site specific data, a test dredge to -42 feet MLLW using a clamshell bucket is being pursued through the O&M dredging program. This data will determine whether additional equipment may need to be mobilized during the construction of the channel improvement project.

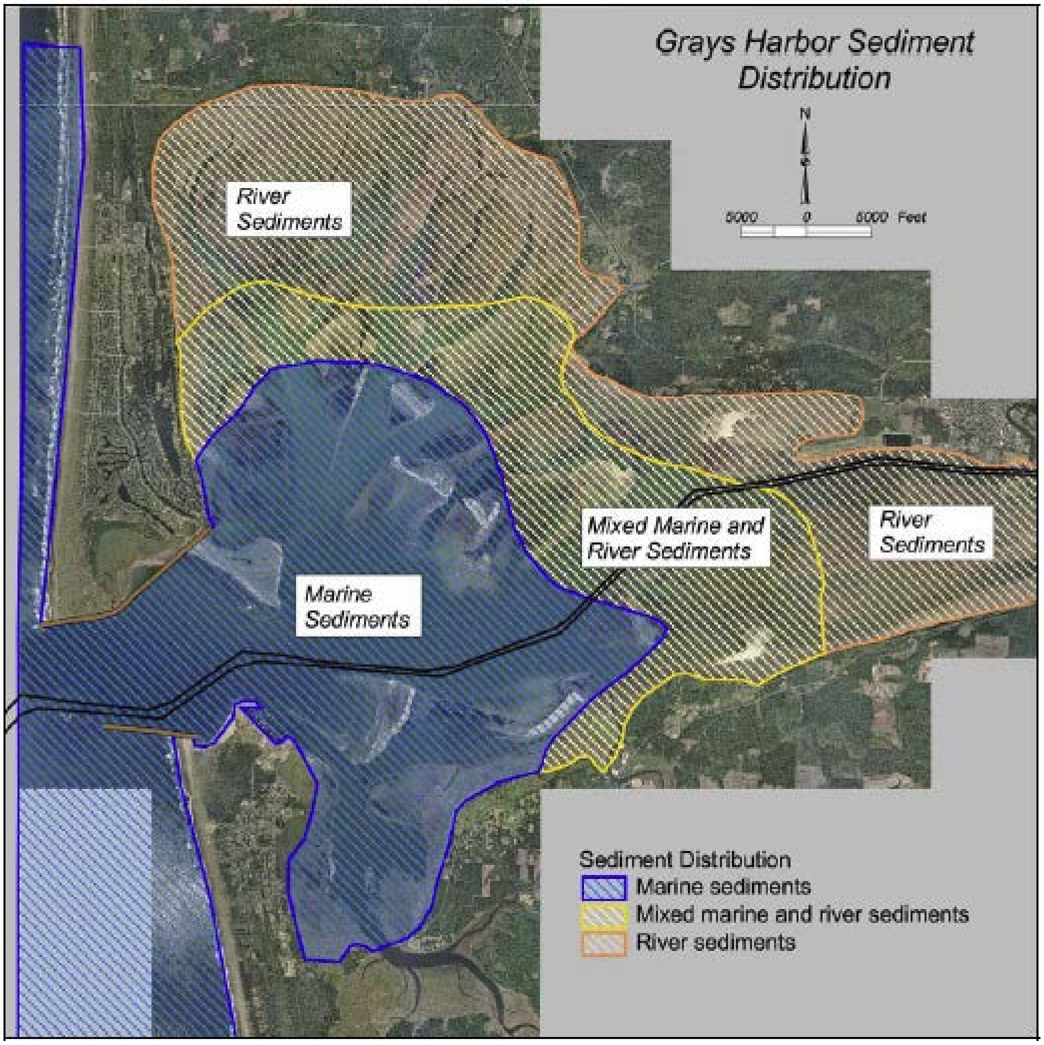

Figure 25: Distribution of sediments within Grays Harbor (from Kraus and Arden 2003; originally depicted by Scheidegger and Phipps (1976)

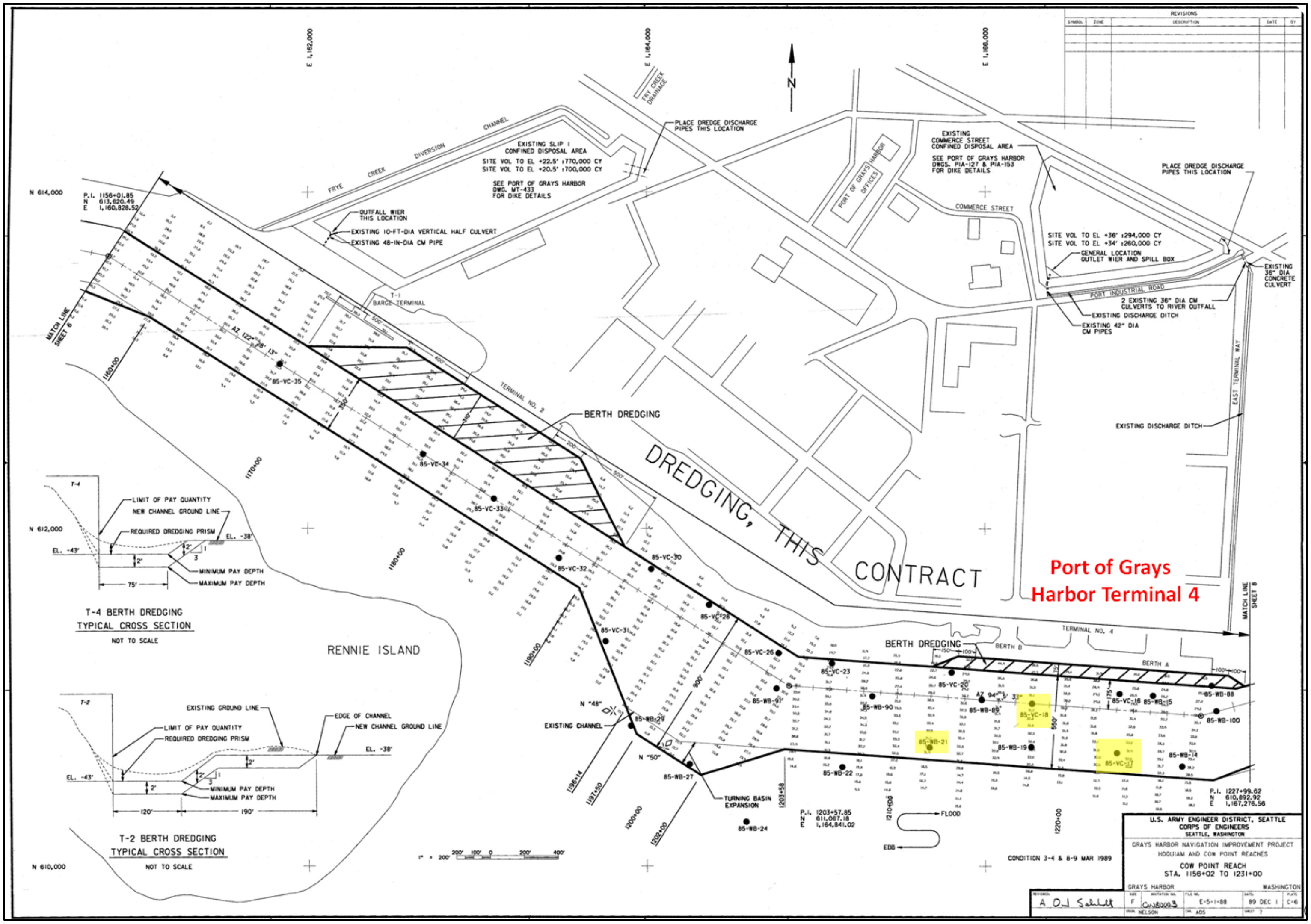

Figure 26: 1985 vibracore and wash-boring test hole locations

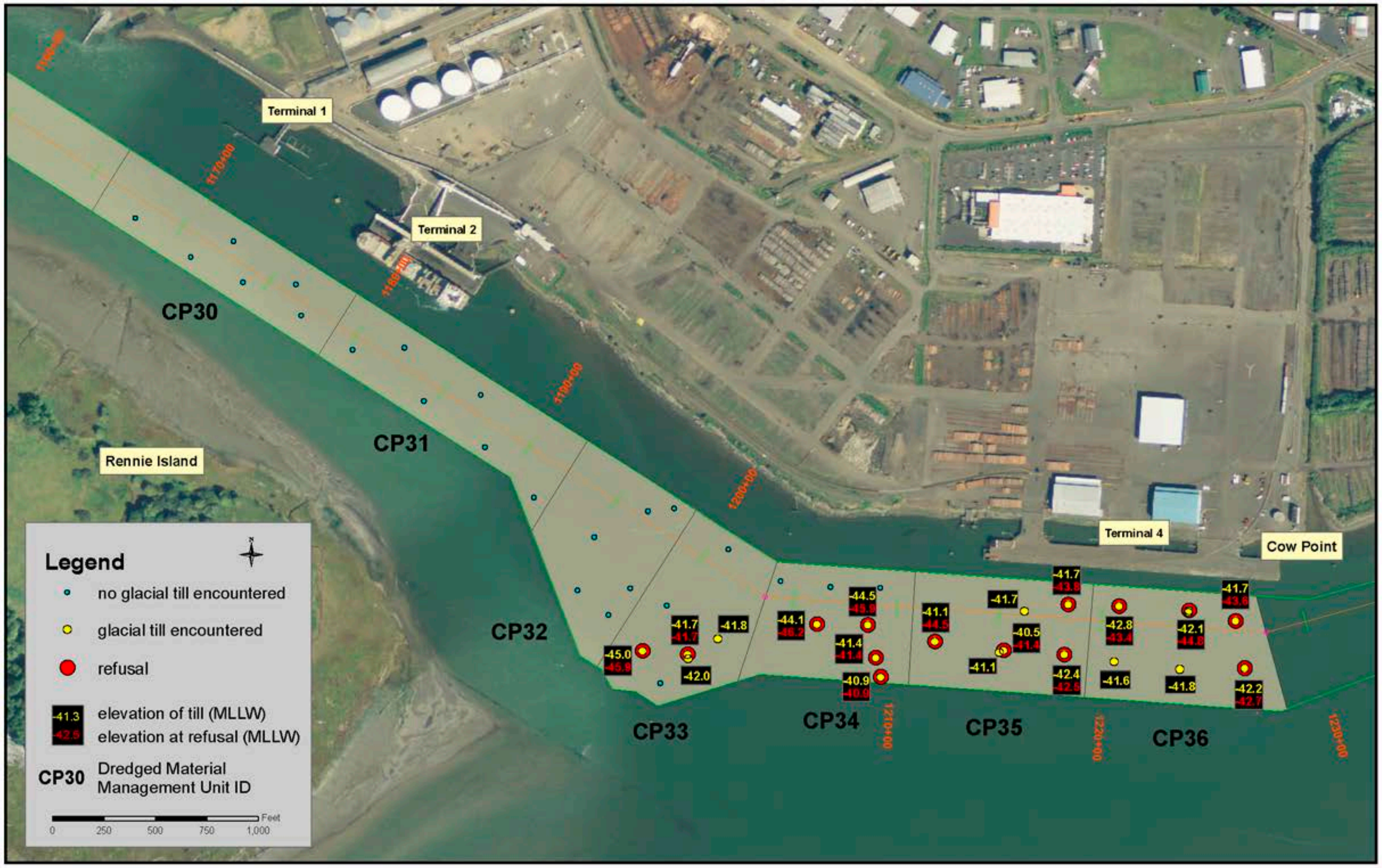

Figure 27**: 2012 Vibracore test hole locations and refusal depths.**

4. Design Considerations

4.1. Vessel Traffic

Vessel traffic has changed since completion of the 1990 Navigation Improvement Project. Historically, deep-draft vessels calling at Grays Harbor were generally limited to foreign export timber carriers. However within the last decade, the Port made a strategic decision to move away from timber exports and diversify to include liquid/bulk and automobile exports. Figure 28 shows a breakout of commodities by vessel draft using the Waterborne Commerce Database[2] (2005-2009). Presently, deep draft vessels calling the Port of Grays Harbor are classified into three main categories; Tanker, Bulker, and Roll On Roll Off (Ro-Ro). In 2012, the Port of Grays Harbor called 83 of these types of vessels. Port arrivals had an average draft of 24.7 feet and a maximum draft of 36.4 feet. Departing vessels from the Port had an average draft of 31.5 feet and a maximum draft of 40.5 feet. This indicates departing vessels (exports) continue to be the design condition for the navigation channel serving the Port.

4.2. Design Vessel

USACE (1989) determined the design vessel for two channel segments within Grays Harbor. At Cow Point Reach and downstream this was determined to be a 37-foot draft, 625-foot length, and 100-foot beam vessel. Upstream of Cow Point this was a 37-foot draft, 600-foot length, and 100-foot beam (note this project does not include any dredging upstream of Cow Point Reach). This design vessel was defined as the size of vessel which carried the majority of cargo versus the maximum-sized vessel that the channel could accommodate. EM 1110-2-1613 (USACE 2006) recommends the designer utilize information on the type of traffic to select the design ship, which is usually the largest ship of the major commodity movers expected to use the project improvements on a frequent and continuing basis.

Deep draft vessels presently calling at Grays Harbor range in size from 10,000 to 75,000 deadweight ton (DWT), with an average of 40,000 DWT. The range in vessels is broader than in 1990 which were listed as 20,000 to 40,000 DWT. Still the present average vessel calling Grays Harbor is approximately 40,000 DWT. Figure 29 shows the vessel dimensions from 2012 versus the USACE (1989) defined design vessel. Note from these figures the previous design vessel captures most of the Ro-Ro and Tanker vessel types. The Bulker vessel type represents the only vessel outside this range. However as these data indicate it is possible to compensate for larger draft vessels by transiting the channel during higher tides. The majority of the vessels with length greater than 625 feet are less than 660 feet, and beams wider than 100 feet are less than 107 feet. The the forecasted vessel fleet is projected to be of the same size as existing conditions. The largest reported vessel leaving the harbor occurred in 2012 and was 75,617 DWT, L = 738 feet, B = 106 feet, D = 40.5 feet. The existing channel width which ranges from 350 to 450 feet meets the recommended guidance of B*3.25 for trench type channel in the 0.5 to 1.5 knots current range per EM 1110-2-1613. The recent channel re-alignment has widened

[2] Waterborne Commerce Statistics Center.
http://www.iwr.usace.army.mil/About/TechnicalCenters/WCSCWaterborneCommerceStatisticsCenter.aspx

three channel bends adding new cutoff turns in the North Channel and Hoquiam Reaches and apex turn in the Inner Crossover Reach. These minor adjustments will better accommodate longer vessels. Vessels with drafts greater than the original design vessel of 37 feet represent less than 4% of the total vessel traffic. These vessel departures all occurred on outgoing tides above +5 feet MLLW. This indicates that the vast majority of cargo transiting the harbor will fall within the present design vessel criteria. Given this information no reason has been found to modify the 1989 design vessel assumptions used for navigation channel design.

4.3. Channel Design

Depth

The inner harbor channel design specified in USACE (1989) included 2.5 feet for minimum safe clearance, 0.5 feet for trim, 0.5 feet for freshwater sinkage, and 1.0 feet for squat. This translates into a design under keel clearance of 4.5 feet. Presently the harbor pilots use a minimum underkeel clearance of 3.5 feet during transits. In this scenario an underkeel clearance of 3.5 feet will suffice as the pilot can reduce the speed of the vessel to negate the effect of squat. Thus the design underkeel clearance remains valid for the current project. In the South Reach, the wave model results presented in Section 1.7 confirm the previous assumption that operational waves in the South Reach are less than two feet in height. Thus no additional depth is necessary to account for ship motion due to waves.

Historic practice at Grays Harbor is for departing vessels to leave the Port terminal near mid tide on an incoming tide. This allows fully loaded vessels to reach the Bar near high tide and safely exit the harbor. Vessel bow movements crossing the Bar have been observed to be on the order of 4 to 14 feet below the water still water line as a result of wave action. Thus vessels crossing the bar must occur near high tide (i.e. mean higher high water). The transit time from Aberdeen to the Bar Reach is approximately 3 hours. Data from the Port indicates the average tide a departing vessel leaving Aberdeen is approximately +6.0 feet MLLW. During transits of vessels with loaded drafts above 37 feet MLLW, this average departure tide was +8.0 feet MLLW.

Width and alignment

A ship simulation study (USACE 1991) was performed to confirm a 350 foot wide channel through the inner harbor reaches was still sufficient for the design vessel. In April 2012, discussions with the Port of Grays Harbor Bar Pilots and the ship simulation manager at the USACE Coastal Hydraulics Laboratory determined the current channel width was sufficient to accommodate the forecasted vessel traffic and a supplemental ship simulation was not necessary for an incremental deepening of 2 feet (USACE 2012).

Through the Operations and Maintenance (O&M) program the Corps initiated a minor re-alignment of the federal navigation channel from South Reach to North Channel ; Sta. 660+00 to 1014+00 (USACE 2013a). The intent of channel realignment was to more appropriately align the channel with the natural thalweg through the inner harbor in effort to reduce annual O&M dredging. This was determined the most sustainable solution as O&M funding has not historically matched the dredging needed to maintain the channel to its fully authorized width and depth in its present location. Channel realignment saves approximately 1 million cubic yards of dredging to obtain a full channel width and depth, and thus also reduces the burdens of dredging and disposal on the ecosystem. Minor adjustments to turns in the channel at Sta. 860+00, 943+00, and 998+00 are required to accommodate the design vessel beam of 100 feet (Figure 30 to 32). These adjustments include modifying an angle turn to a cutoff turn at Sta.

943+00 and modifying a cutoff turn to an apex turn at Sta. 860+00 as required by EM 1110-2-613 (USACE 2006).

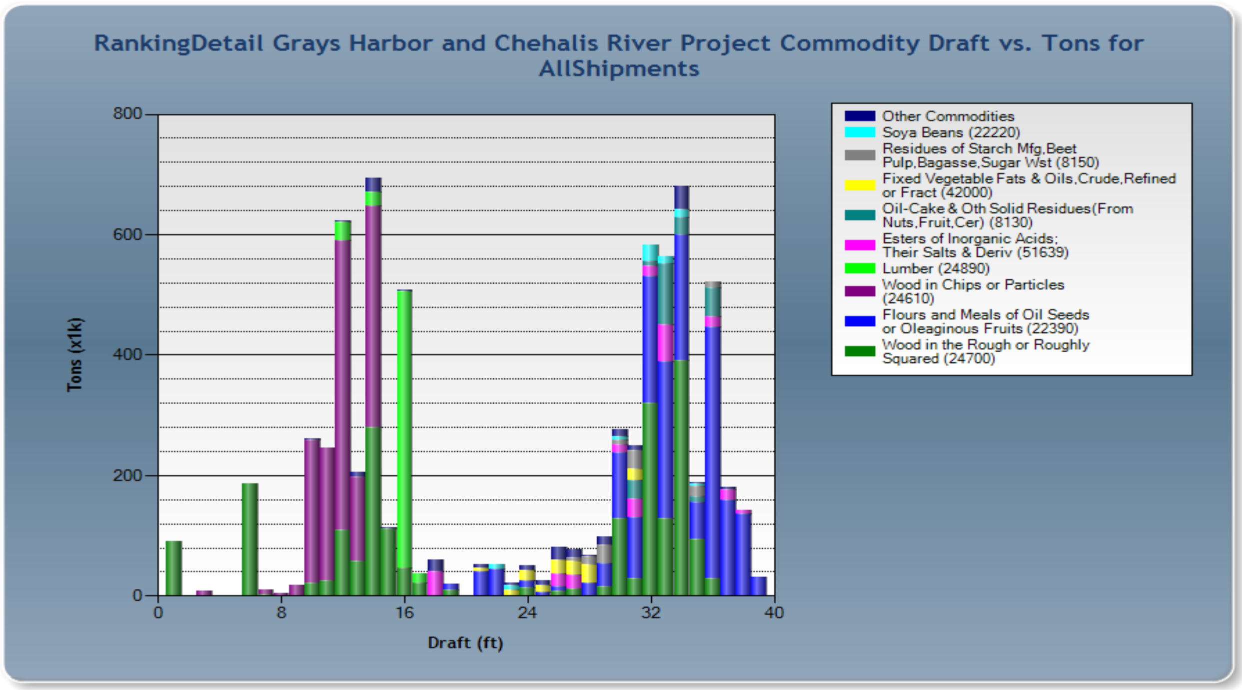

Figure 28: Tonnage by draft at Grays Harbor (2005-2009). Source: Waterborne Commerce Database

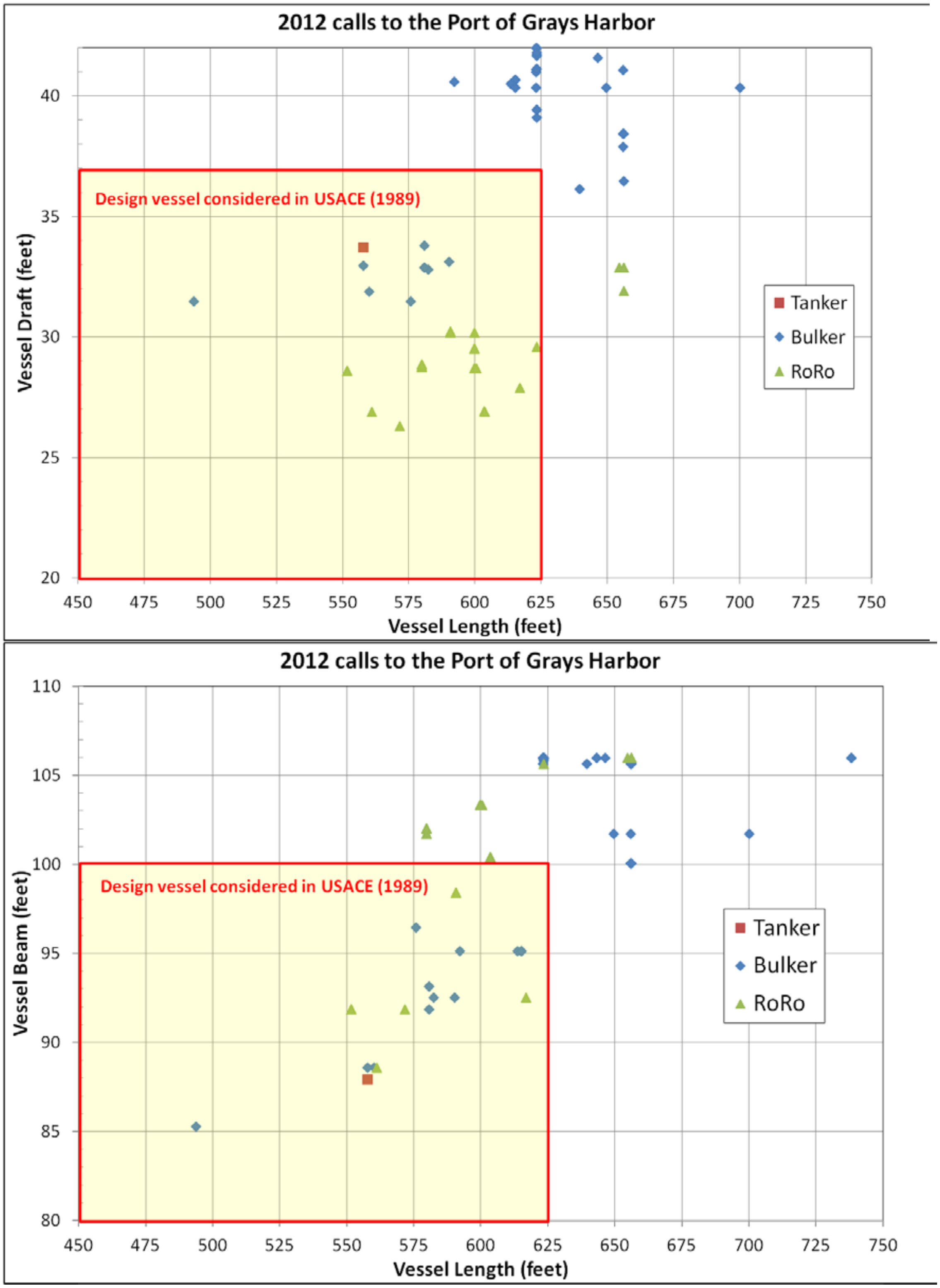

Figure 29: 2012 calls to PGH relative to the USACE (1989) design vessel (a) length/draft (b) length/beam

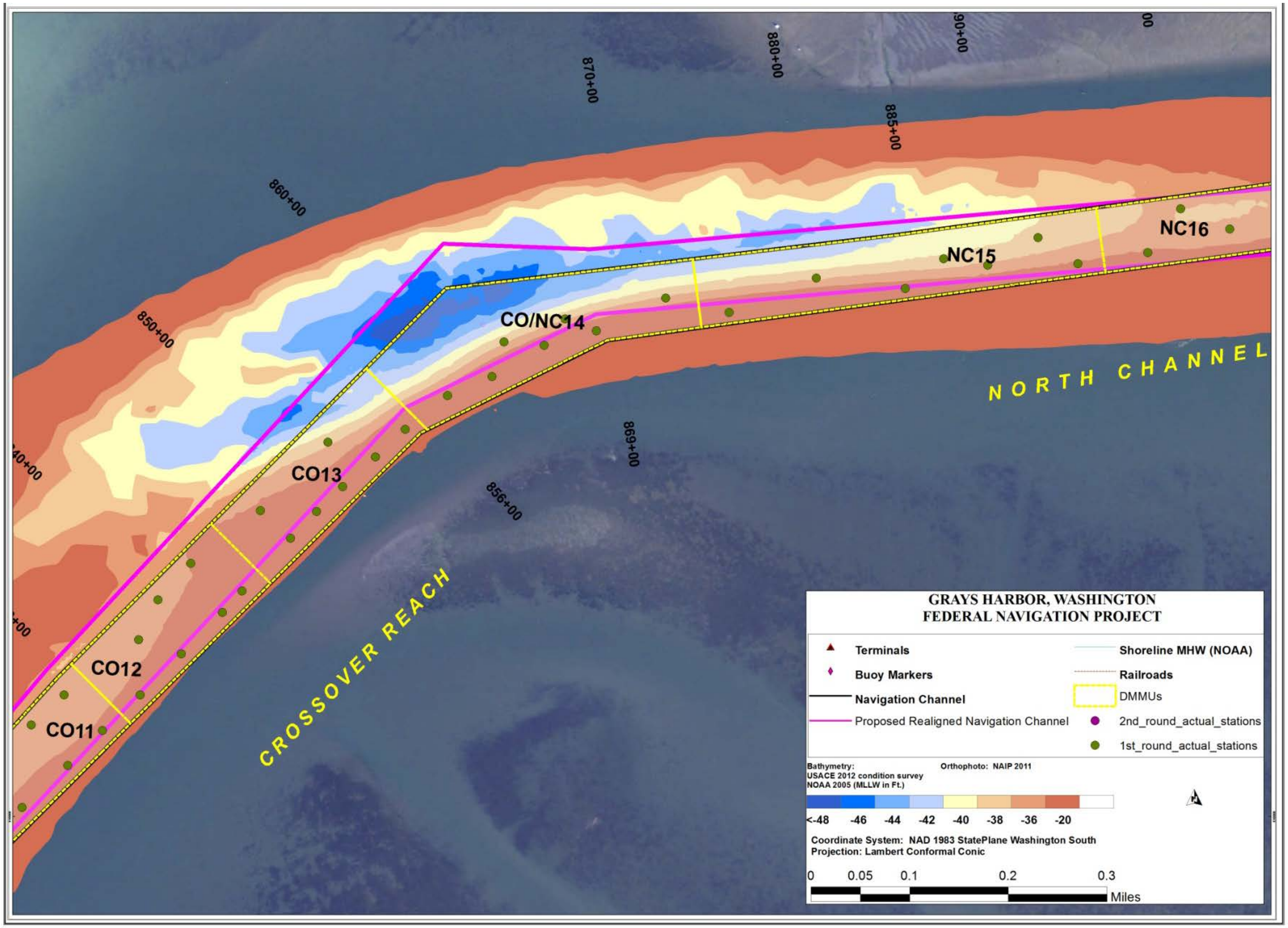

Figure 30: Minor channel re-alignment channel turn modification (in pink) at Sta. 860+00.

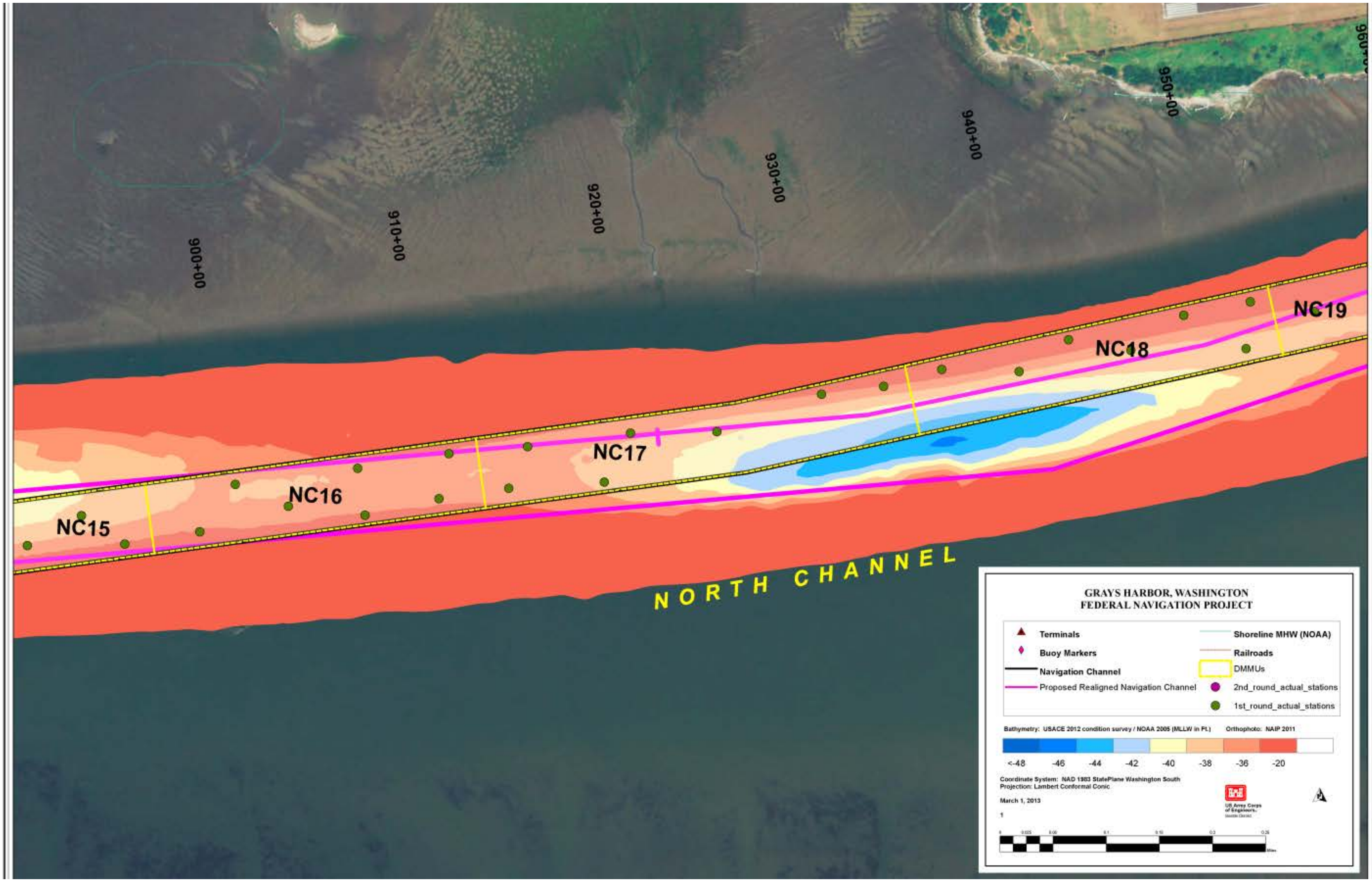

Figure 31: Minor channel re-alignment channel turn modification (in pink) at Sta. 943+00.

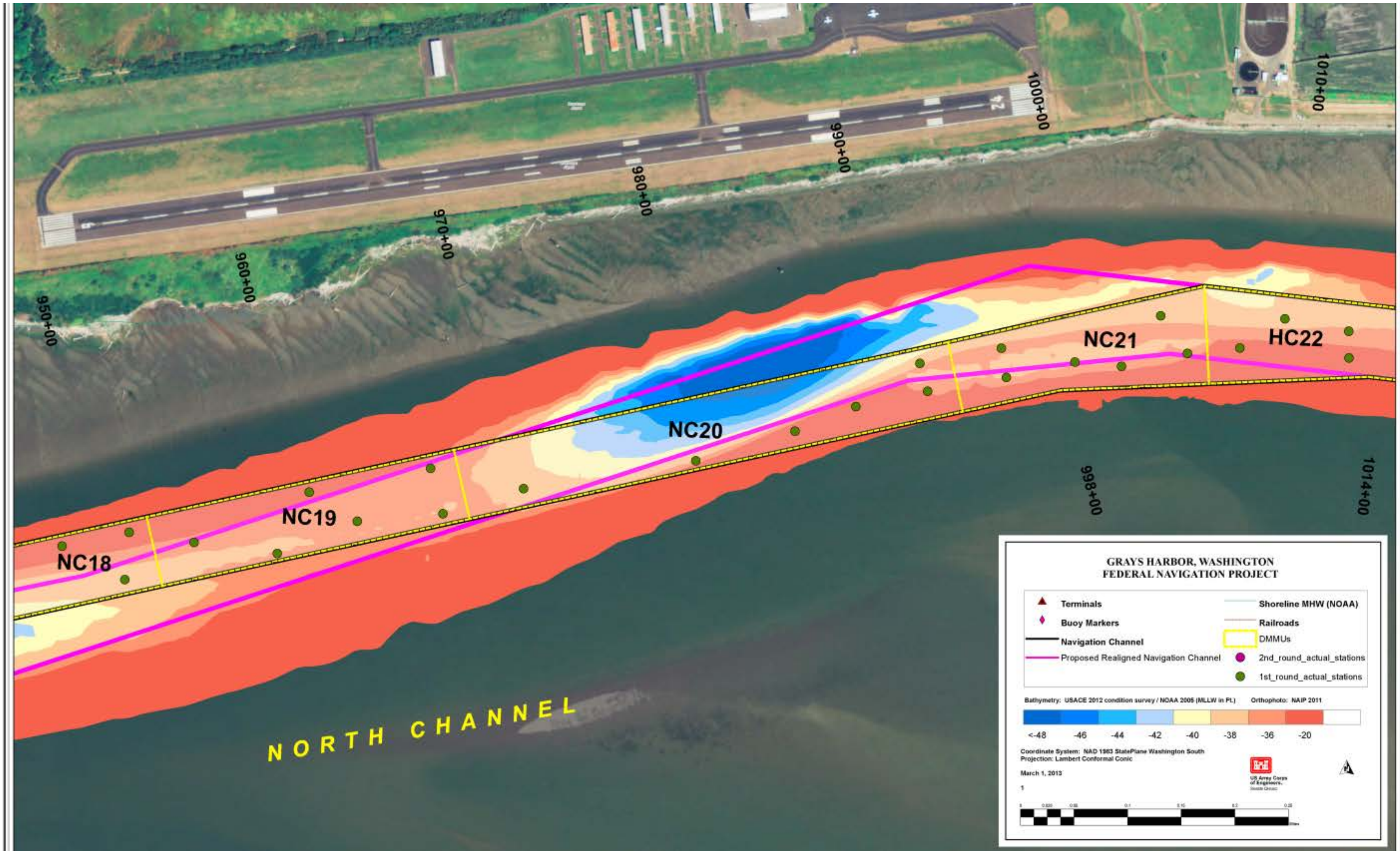

Figure 32: Minor channel re-alignment channel turn modification (in pink) at Sta. 998+00.

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4.4. Dredging and placement of dredged materials

Three alternatives are considered in the Limited Revaluation Report.

- Alternative 1: No Action – maintain current project depth of -36 feet MLLW
- Alternative 2: Deepen project depth 1 foot to -37 feet MLLW
- Alternative 3: Deepen project depth 2 foot to -38 feet MLLW

The maximum allowable dredging depth for each alternative includes 2 feet of advanced maintenance dredging and 2 feet of allowable overdepth tolerance. For each alternative it is assumed the channel would be dredged to its maximum allowable depth and width. It is also assumed that deepening would be performed concurrently with O&M dredging and would be performed in one dredge year. Thus the open water dredged material placement sites require sufficient capacity to accept all O&M and deepening material in one dredging year.

4.4.1. Dredged material quantities

Table 7 lists dredged volumes to obtain the maximum allowable dredge depth for each of the three alternatives. This volume ranges from 2.5 to 4.2 million cubic yards (including both O&M and channel improvement dredging, as applicable). Of this quantity the incremental volume representing only channel deepening represents 0.8 million cubic yards for Alternative 2 and 1.8 million yards for Alternative 3.

4.4.2. Dredging schedule and production

For the inner harbor dredging in order to meet a one year construction schedule it is assumed the daily production will be increased by mobilizing a second clamshell dredge and two additional bottom dump scow barges to dredge the Inner Harbor reaches to their maximum allowable depth. Based on the September 2012 condition survey, the maximum allowable clamshell dredging volume for Alternative 2 is 3.07 million cubic yards and 3.87 million cubic yards for Alternative 3..

There are 214 available work days in the work window from July 15 to February 14. Thus a daily production of 16,000 cubic yards is required to complete construction in one year.

Recent O&M dredging production in the inner harbor has averaged 12,000 cubic yards per day. This includes a 35 cubic yards clamshell bucket and 2 bottom dump barges (1 – 1800 cubic yard and 1 – 4000 cubic yard scow) for open water placement at the Point Chehalis and South Jetty estuarine placement sites. In order to estimate the daily production of new material associated with deepening, production rates from the 1990 deepening project and the 2006 O&M clamshell dredging were reviewed. The 1990 Channel Deepening project removed 2.2 million cubic yards from the Crossover and North Channel Reaches with an average daily production of 16,628 cubic yards per day. The 2006 O&M dredging removed material below -40 feet MLLW throughout the inner harbor reaches using a 26 cubic yard clamshell bucket and 2 – 7,200 cubic yard scows). The average daily production across all reaches was 13,127 cubic yards per day and is considered to be a representative estimate of the combined O&M and new work dredging. Thus it is assumed by mobilizing a second dredge and 2 additional scows daily production would increase to approximately 24,000 cubic yards per day. This translates to 128 dredging days for Alternative 2 and 162 dredging days for Alternative 3.

The outer harbor dredging in South Reach will be dredged with a hydraulic hopper dredge. The maximum allowable hopper dredging volume for Alternative 2 is 0.17 million cubic yards and 0.32 million cubic yards for Alternative 3. Typically the government hopper dredges maintain these channel reaches. At Grays Harbor, historically the production of the *Essayons* is approximately 30,000 cubic yards per day and the *Yaquina* is 10,000 cubic yards per day. For each hopper dredge this would translate to an additional 5 dredging days for Alternative 2 and an additional 8 dredging days for Alternative 3.

4.4.3. Placement of dredged materials

All dredged material was found to be suitable for open water placement except for one dredged material management subunit in the Cow Point Reach. This volume is approximately 22,400 cubic yards (USACE 2013b) for Alternative 3 and will be placed in a designated upland site. The remaining dredged materials will be placed at the Point Chehalis and South Jetty open water placement sites (Figure 33).

4.4.3.1. Open water placement sites and capacity

O&M and channel improvement dredged materials will be placed at the Point Chehalis Site (PCS) and South Jetty Site (SJS). The PCS and SJS are dispersive open water estuarine sites managed by Washington State Department of Natural Resources (WSDNR). As listed in Table 8, on average the Corps places 960,300 cubic yards at the PCS and 576,400 cubic yards at the SJS each year. The maximum cumulative quantity placed at both sites in one year was 2.2 million cubic yards. For comparison, for Alternative 3 the total O&M and deepening dredged volume is 4.2 million cubic yards in the single construction year, or almost two times this amount.

Due to the dispersive nature and amount of sediment transported outside of the site boundaries as suspended sediment during placement, both the PCS and SJS have a larger capacity than the volume released from the bottom dump barge. Incorporating this dispersive nature into the management of a site is typically referred to as dynamic capacity of a site. Analysis of historic open water placement of O&M sediments from the channel indicate at the dynamic capacity at each site can be as large as three times the static capacity, or in other words 67% of the sediments placed at a site are transported outside of the site boundaries in one year, either as suspended load during placement or as bedload following its placement. Currently open water placement of O&M dredged materials are limited to the northern half of the PCS as material placed in the southern half results in a significant amount of sediment that re-enters the navigation channel which would require re-dredging.

Based on sediment transport modeling and Sedflume analysis conducted (Demirbilek et al. 2010; Hayter et al. 2012) it was determined placing all dredged material within the current PCS boundaries may pose an adverse risk to navigation and O&M dredging costs. The federal navigation channel passes through the site and mounding of material can result in loss of channel depth and width without proper site management. This conclusion was made by modeling multiple placement scenarios representing different volumes of dredge material, different fractions of sediment clumps (i.e. consolidated sediments which form large clumps), and different placement site boundaries (the current site and a modified site). As shown in Figure 34, model results indicate that larger sediment clump fractions have a significant impact on mounding at the placement sites. For instance as shown in Figure 34a, the maximum computed mound height in the Point Chehalis site was 8.5 feet for a 10-percent clumping fraction. This height increases to 20.7 feet for a 50-percent clumping fraction (Figure 34b). As channel deepening sediments are likely more consolidated than newer O&M sediments it is likely that the transport rate at each of the sites will be slower than historically observed during placement of O&M dredged material. Model results suggest that utilizing current placement practices at the Point Chehalis site, more than half the navigation channel width would shoal in above the authorized depth when a 50% sediment clumping fraction is assumed for the sediments placed at the site. Thus, solely using the northern half of the Point Chehalis Site as currently managed is likely to create adverse shoaling in the Point Chehalis Reach of the federal navigation channel. In order to safely accommodate both the O&M dredged material and the channel deepening material, it is necessary to shift the Point Chehalis placement site boundaries 1,000 feet northwest for the single construction year. This shift would provide greater static capacity (i.e. deeper depths) as well as preferential transport pathways which minimize the amount of sediments re-entering the navigation channel. Figure 35 shows the computed mound heights for the same quantity with the shifted site boundaries. In this scenario the shifted boundaries alone, reduced the loss of authorized depth in the navigation channel to only 8% of the channel width. The modeling simulations assumed uniform placements over the entire placement area. Therefore it is speculated that impacts to navigation could be further reduced by concentrating more placements in the eastern sector of the site where depths are greater.

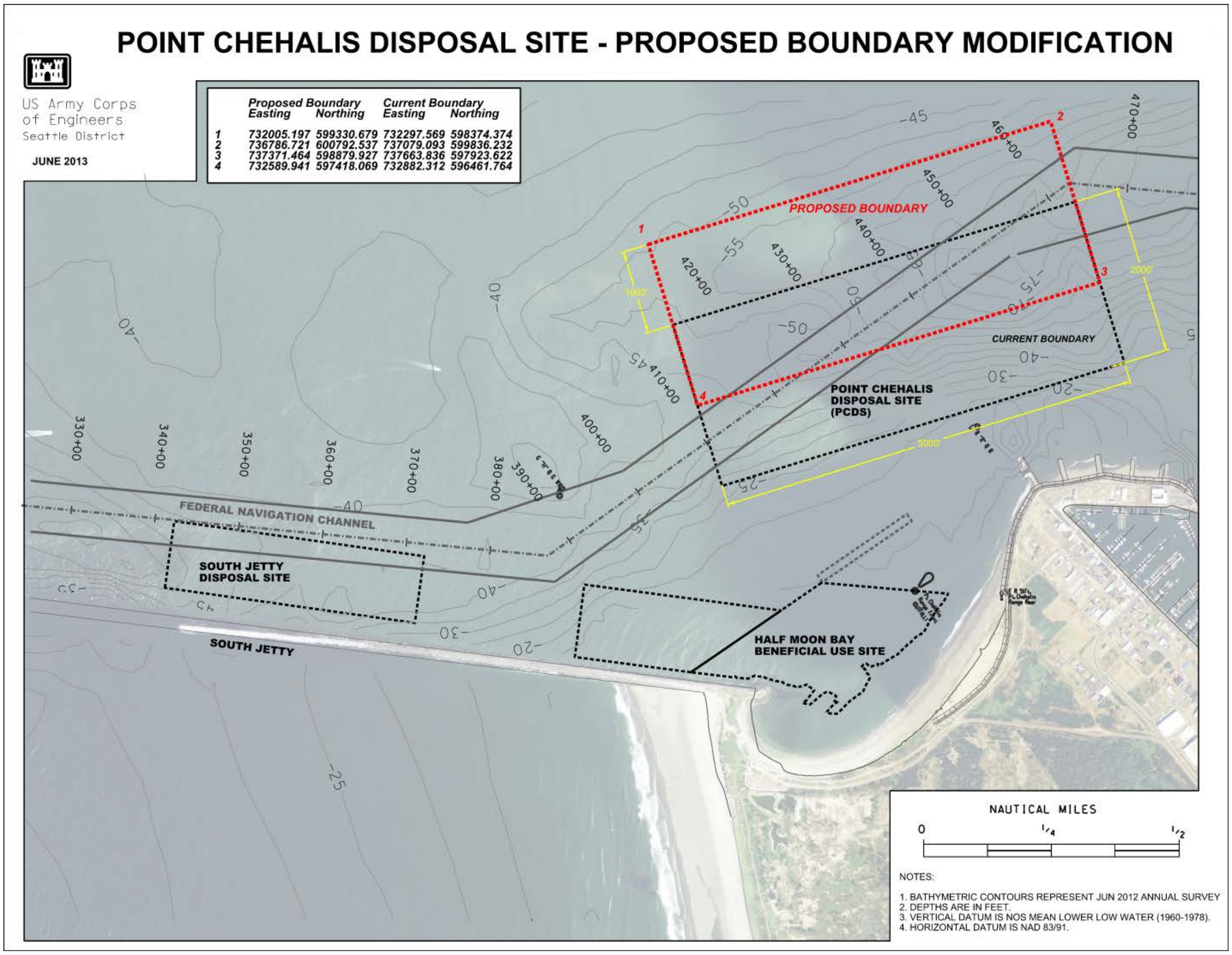

Figure 33: South Jetty Site (SJS) and Point Chehalis Site (PCS) with boundary modification (in red)

Table 7: Grays Harbor Navigation improvement Project Dredge Volumes to maximum allowable dredging depth

Channel Reach	Stationing	Side Slope	Alt 1 (-40' MLLW) Volume (cubic yards)[3,4]	Alt 2 (-41' MLLW) Volume (cubic yards)[2,3]	Alt 3 (-42' MLLW) Volume (cubic yards)[2,3]
South Reach	463+00 to 716+88	1:5	78,674	163,874	318,332
Outer Crossover	716+88 to 795+00	1:5	208,325	310,865	451,485
Inner Crossover	795+00 to 871+12	1:5	393,042	528,381	662,640
North Channel	871+12 to 1009+24	1:3	282,401	432,068	599,140
Hoquiam Channel	1009+24 to 1159+50	1:3	622,144	799,609	986,417
Cow Point	1159+50 to 1231+48	1:3 / 1:1.5	856,766	994,891	1,168,614
TOTAL			**2,441,352**	**3,229,688**	**4,186,628**

[3]Assumes minor channel realignment initiated from South Reach to Hoquiam Reach (channel stationing 660+00 to 1014+00)

[4]Volumes are computed relative to the Seattle District September 2012 condition hydrosurvey and supplemented with NOAA 2005 hydrosurvey in areas without coverage; volumes include 15% contingency

Table 8: Placement Volumes (2000-2012)

	Pt. Chehalis (open water)	South Jetty (Open water)	HMB (Nearshore)	South Beach (nearshore)	Pt Chehalis Stockpile mitigation (upland)	Total
2000	956,700	1,200,248	0	0	0	2,156,948
2001	667,943	358,873	0	0	0	1,026,816
2002	942,310	475,199	378,441	75,219	705	2,006,874
2003	355,139	824,694	329,107	125,388	0	1,634,328
2004	957,186	1,166,089	289,652	262,176	-45,000	2,675,103
2005	1,054,086	740,970	102,194	217,909	0	2,115,159
2006	1,277,837	196,833	126,892	55,170	0	1,656,732
2007	599,254	389,127	140,406	0	0	1,128,787
2008	1,288,726	707,080	171,352	0	0	2,167,158
2009	1,223,159	21,088	144,975	214,502	0	1,603,724
2010	977,282	91,720	91,720	118,182	-30,000	1,278,904
2011	702,650	1,000,925	177,150	298,251	0	2,178,976
2012	1,481,714	320,985	111,205	142,313	0	2,086,217
TOTAL	12,483,986	7,493,831	2,063,094	1,509,110	-74,295	23,715,726
AVG. ANNUAL	**960,300**	**576,400**	**158,700**	**116,100**	**-5,700**	**1,896,000**

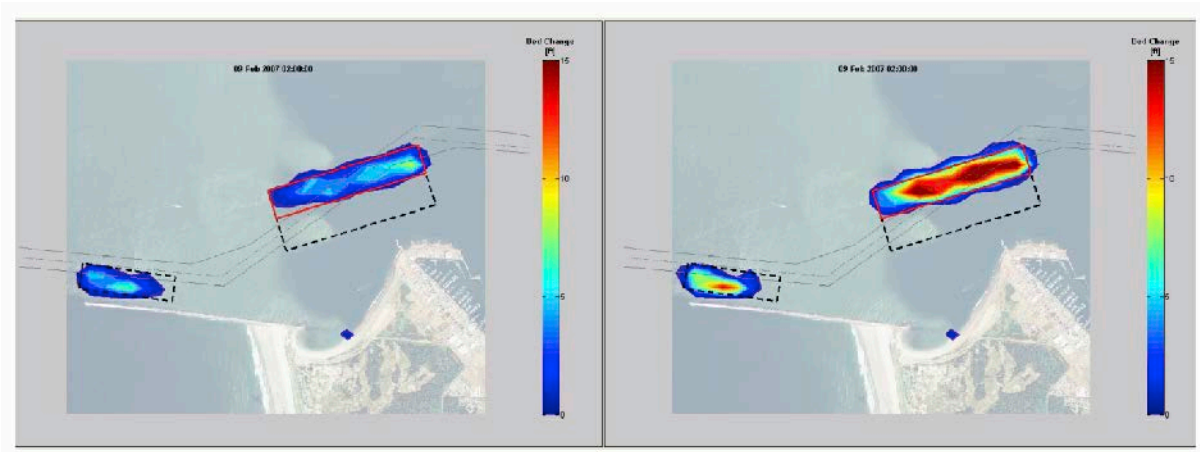

Figure 34: Dredge material mound heights following 10 month simulation for (a) 10 percent and (b) 50 percent clumping fractions for Scenario 1 which assumes 4.5 million cubic yards of dredged material is placed using *current* Point Chehalis site placement practices (from Hayter et al. 2012).

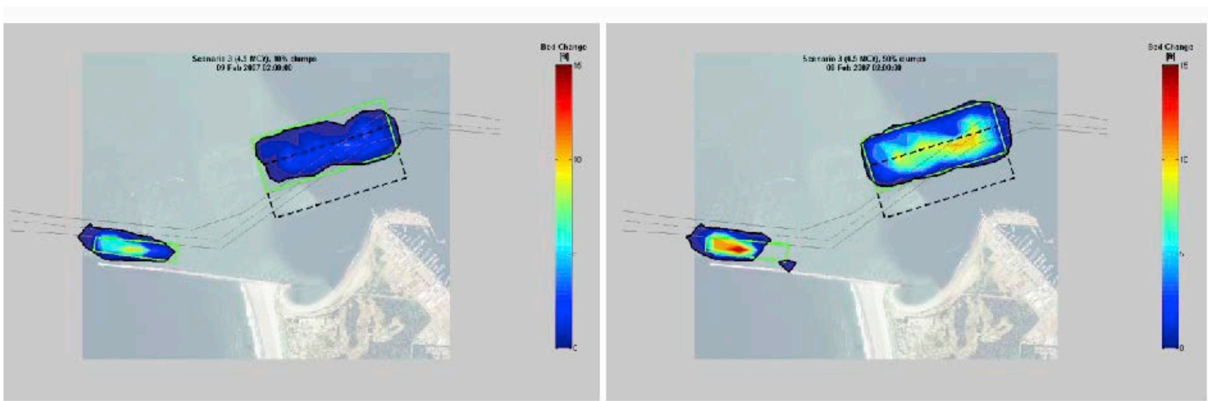

Figure 35: Dredge material mound heights afeeter 10 month simulation for (a) 10 percent and (b) 50 percent clumping fractions for Scenario 3 which assumes 4.5 Mcubic yards of dredged material is placed using a *modified* Point Chehalis site boundary.

4.4.3.2. Beneficial Use Sites

During construction of the navigation improvement project, O&M dredged materials from the outer harbor reaches will be placed in the Half Moon Bay and South Beach Beneficial Use Sites which will help to maximize capacity of the PCS and SJS. Beneficial use sites have annually received 158,700 cubic yards and 116,100 cubic yards respectively since 2000. The South Beach Beneficial Use Site (SBBUS) has significantly more capacity to receive dredged material than what has been historically placed here. The static capacity computed in March 2013 at the SBBUS is over 1.5 million cubic yards with a dynamic capacity of over 3.0 million cubic yards. Thus during the year of construction of the deepening project, over 90% of all O&M dredged materials from the Bar, Entrance, and Point Chehalis reach will be directed for placement at the SBBUS or HMBBUS. Additionally deepening material from South Reach is suitable for placement at the South Beach or Half Moon Bay beneficial use sites; however in the capacity analysis it is assumed to all be placed at the Point Chehalis (PCS) or South Jetty Site (SJS).

4.4.3.3. Upland placement

Chemical analysis conducted in 2012 found subunit CP32a in the Cow Point reach to be unsuitable for open water placement. The quantity of material is estimated to be approximately 22,400 cubic yards. This material will need to be placed in a designated upland placement site. The Port of Grays Harbor has identified a location with sufficient capacity to accept this material in the former waste water treatment lagoons near Port Terminal 3 in Hoquiam. The lagoons already have berms constructed around the site and are pursuing additional fill material,. Real estate has acquired easements for this site as shown in Figure 37. The methodology for placing the material is assumed to be via clamshell and barge with mechanical rehanding of material. During dredging the barge would be lined with geotextile fabric to prevent leakage. The barge would be dewatered through a sump pump with a geofabric bag surrounding the discharge pipe to contain sediments.

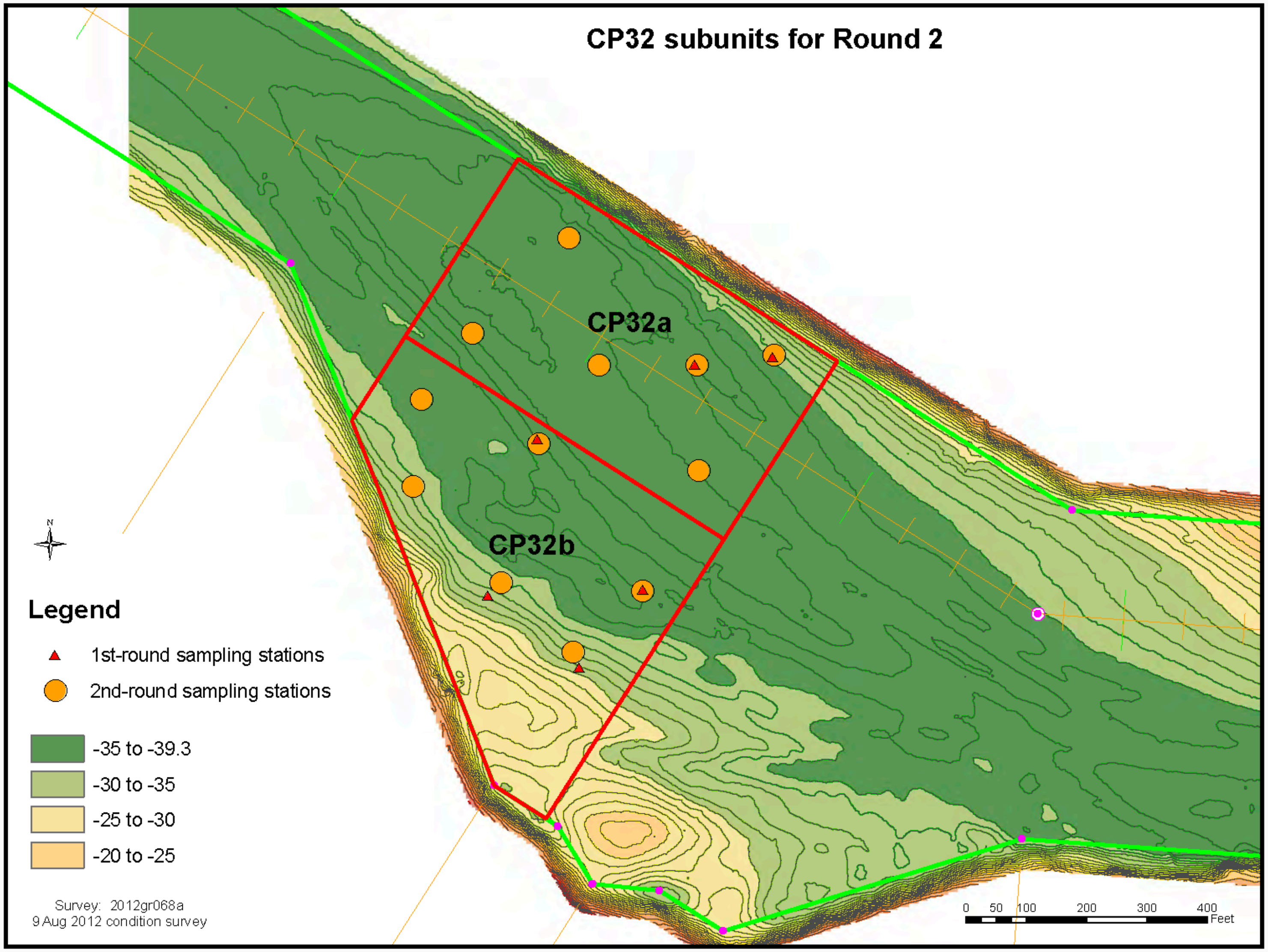

Figure 36: Unsuitable dredged material in Cow Point Reach (sub-unit CP32a; volume = 22,400 cubic yards)

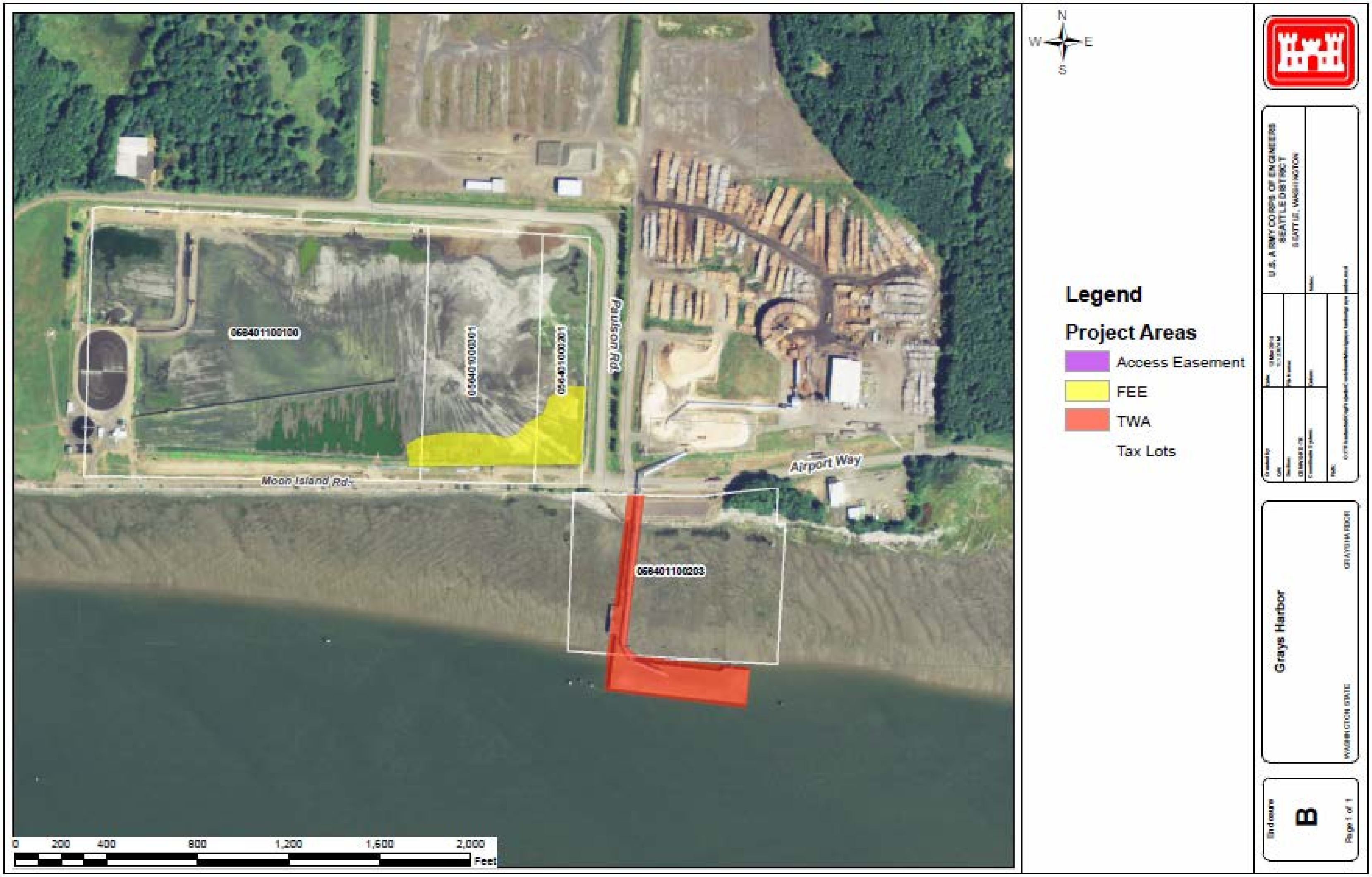

Figure 37: Upland placement location (in yellow)

5. Operations and Maintenance

Historically channel deepening and widening projects result in a net increase in O&M dredging requirements. This has been well documented by Rosati (2005) which shows a net increase in O&M dredging over six historic deepening and widening projects. An empirical relationship was also developed which relates the volume deficit, or the volumetric difference between the dredged and natural equilibrium channel geometry. A linear regression using historic data indicates the annual increase in dredging is approximately 6% of the volume deficit. Thus for this project the volume deficit would be increased by approximately 1.75 million cubic yards for Alternative 3. Using this relationship the predicted increase in O&M dredging associated with the project would be 0.0613*1.75 = 106,985 cubic yards per year. Table 9 presents this by channel reach. This assumption assumes linear shoaling across the entire channel length which is not necessarily the case at Grays Harbor, but serves as a first level estimate for project planning.

Table 9: Grays Harbor Navigation Improvement Project Alternatives - Dredge Volumes to maximum allowable dredging depth

Channel Reach	Stationing	Side Slope	Alt. 2. Volume deficit (cubic yards)	Alt. 2 Increase in O&M dredging (Rosati 2004) (cubic yards)	Alt. 3. Volume deficit (cubic yards)	Alt. 3 Increase in O&M dredging (Rosati 2004) (cubic yards)
South Reach	463+00 to 716+88	1:5	85,200	5,223	239,658	14,691
Outer Crossover	716+88 to 795+00	1:5	102,540	6,286	243,160	14,906
Inner Crossover	795+00 to 871+12	1:5	135,339	8,296	269,598	16,526
North Channel	871+12 to 1009+24	1:3	149,667	9,175	316,739	19,416
Hoquiam Channel	1009+24 to 1159+50	1:3	177,465	10,879	364,273	22,330
Cow Point	1159+50 to 1231+48	1:3 / 1:1.5	138,125	8,467	311,848	19,116
TOTAL			788,336	48,325	1,745,276	106,985

5.1. Outer Harbor Channel Reaches

O&M dredging in the South Reach and Outer Crossover reaches are primarily influenced by bank encroachment and deposition of sediments as sediment is transported across the channel. Thus dredging is typically focused on one side of the channel. Historic O&M dredging has focused on dredging the sideslopes of the channel to minimize bank encroachment. At the South Reach bank encroachment occurs on the north side of the channel as discussed in Section 2.3. The minor channel realignment which will have been implemented by the time of the channel improvement project will significantly reduce dredging in the South and Outer Cross-over reaches.

5.2. Inner Harbor Channel Reaches

O&M dredging in the inner harbor reaches is a result of both bank encroachment and deposition of sediments resulting from the sediment load from the Chehalis River. Shoaling is heaviest in the Cow Point Reach of the federal navigation channel. The channel widens from 350 feet to 950 feet in the turning basin. This effectively increases the cross-sectional area of the channel and thereby reduces the velocity of flows transporting sediments from the Chehalis River and in turn creates deposition in the channel. Additionally the confluence of the south channel immediately south of the turning basin is capable of capturing flow which further dissipates velocity. The intensity of shoaling in the Cow Point Reach and turning basin has historically been correlated with the annual sediment load from the Chehalis River. It is not uncommon to experience shoaling rates of greater than 10 feet between dredge cycles in the turning basin and navigation channel adjacent to the Port of Grays Harbor Terminal 4 (Figure 38). Figure 39, displays the intensity of shoaling in feet in the Cow Point reach between the post dredge survey conducted in February 2013 and the pre-dredge condition survey conducted in August 2013.

Figure 40, displays the intensity of shoaling in feet in the Cow Point Turning Basin which is influenced primarily by deposition from sediment coming from the Chehalis River. Deposition in the southern portion of the turning basin exceeded 7 feet in the 2013 dredge year. It is assumed this area will capture more of the sediment load when the channel improvement project is implemented.

6. Implications of Sea Level Change

The project covers 14.5 miles of the existing channel. The range of sea level change scenarios identified in Section 1.4 varies between 0.24 and 2.0 feet by 2065. The project area does not have any bridge crossings within the reaches being deepened and thus clearance issues associated with sea level rise are not a factor. Existing bridges are located upstream in the navigation channel in the Aberdeen Reach. These include the Union Pacific Railroad Bridge and the WA Route 101 Bridge. Deck heights at the Port of Grays Harbor Terminals are above 18 feet MLLW, thus will not be impacted by sea level change. The greatest impact from sea level change is likely the morphology near the inlet throat. As discussed in Section 2.3, the growth of Damon Point has constricted the inlet throat which has forced the thalweg into the inner harbor to maintain a position where the South Reach channel currently is aligned. Diminishing sediments feeding Damon Point coupled with sea level rise could result in breaches through Damon Point opening new channels into the inner harbor. Should a breach through Damon Point result in a permanent channel into the inner harbor, this could result in greater O&M dredging requirements in the South Reach.

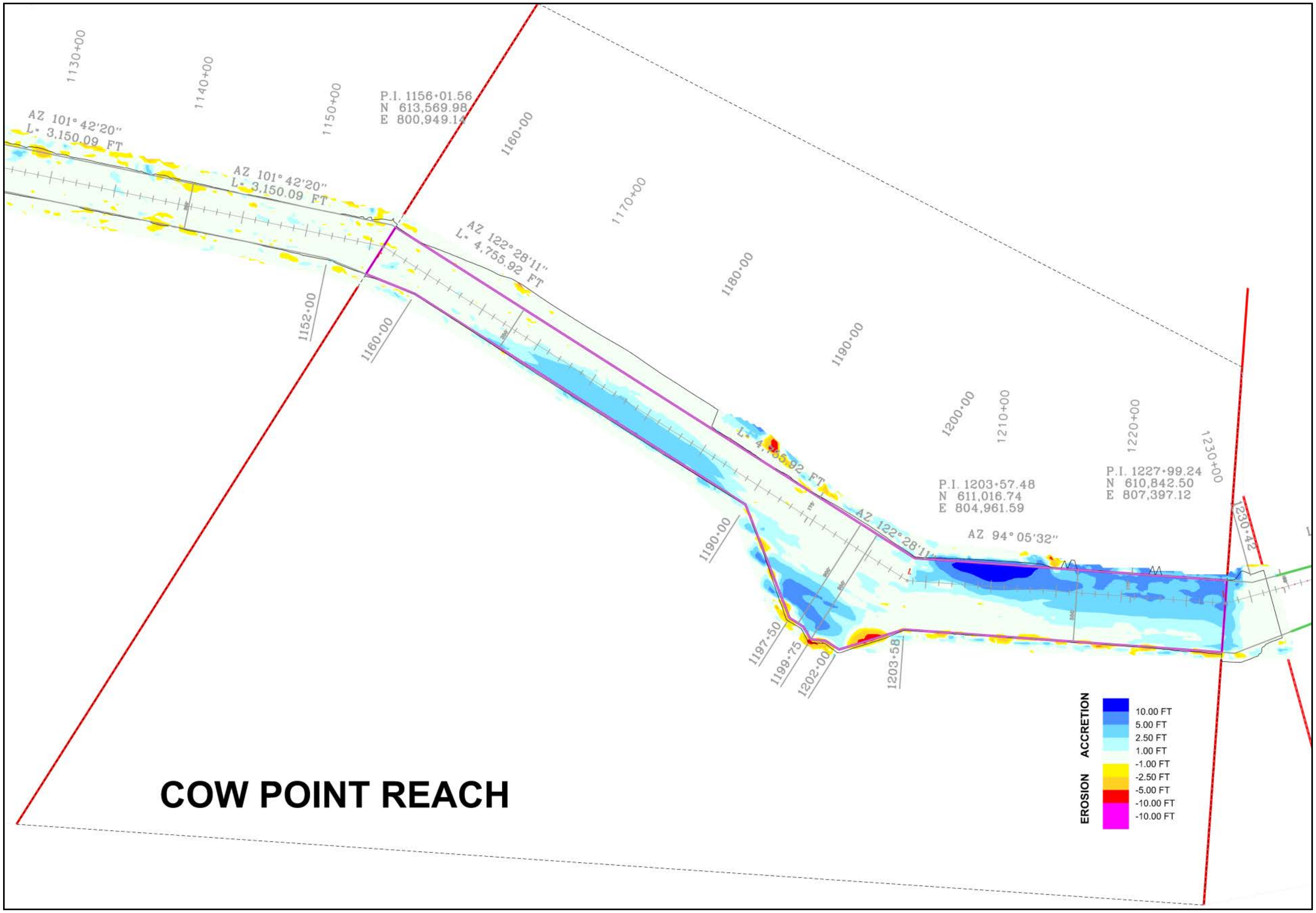

Figure 38: Shoaling (in feet) in Cow Point Reach from February 2013 to August 2013. Net shoaling volume = 212,132 cubic yards

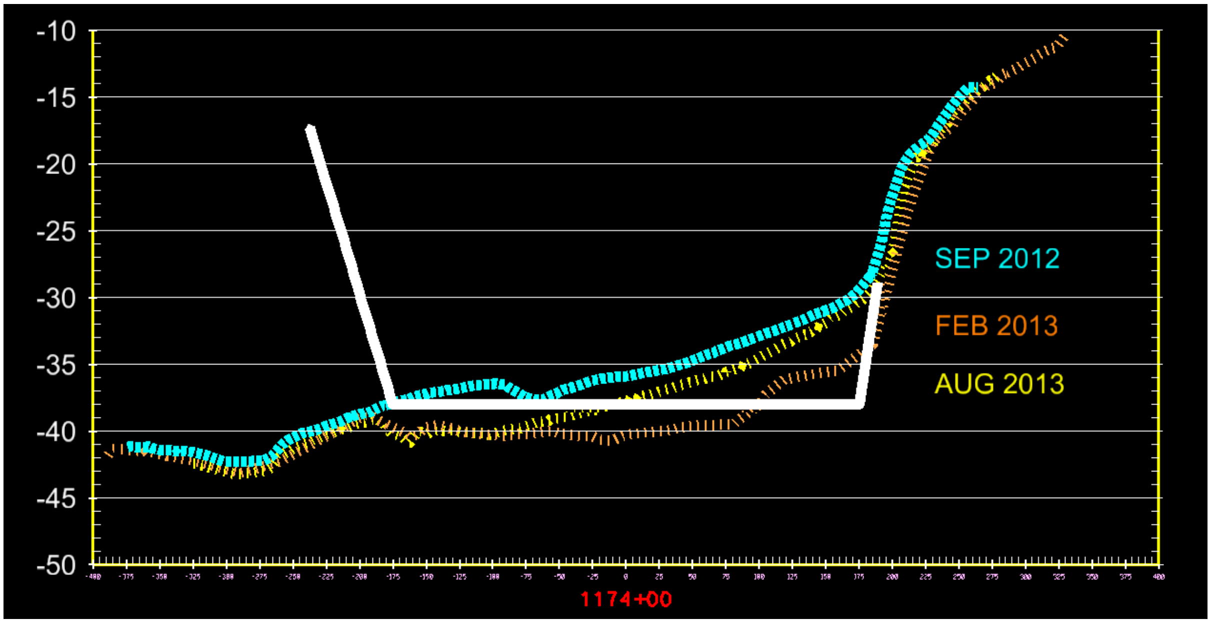

Figure 39: Example of dredging and shoaling in Cow Point Reach over one dredge year. Note after-dredge survey (FEB 2013) indicating bank encroachment from the right bank and up to 5 feet of deposition in the channel at the time of the following pre-dredge survey (AUG 2013).

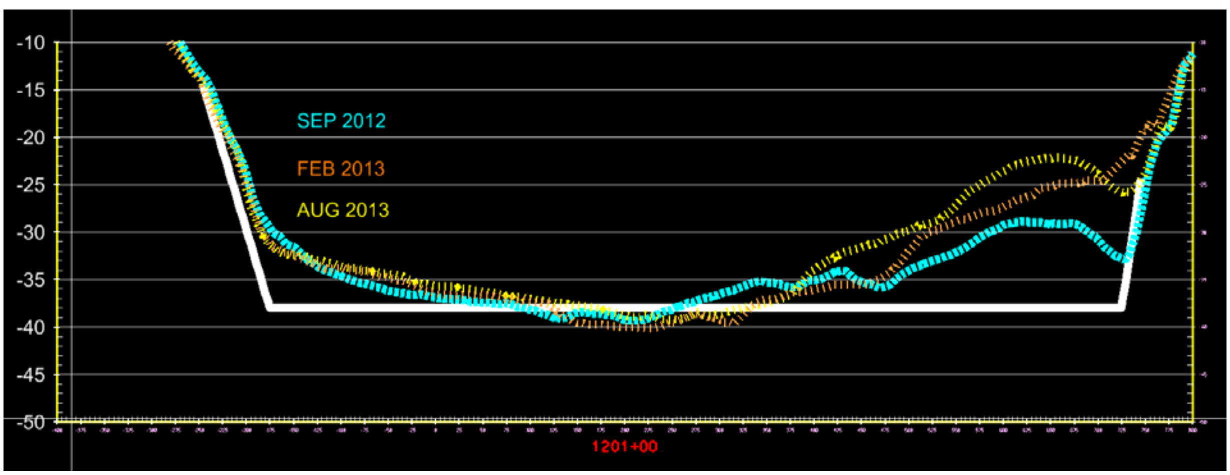

Figure 40: Example of deposition in the Cow Point Turning Basin over one dredge year. Comparing pre-dredge survey (SEP 2012) to following pre-dredge survey (AUG 2013) up to 7 feet of deposition occurred in the turning basin.

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